DEVELOPMENT OF TOP KEY PERFORMANCE INDICATORS FOR ENHANCING HSE COMMITMENT IN SELECTED COMPANIES

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ABSTRACT

Enhancing awareness regarding health, safety, and environmental (HSE) matters would alone not enforce managers to follow HSE requirements in practice. The HSE culture in business is constructed based on the outcomes of practices in the short term. In fact, managing HSE performances in the short term would shape HSE culture in the long term.

A proper safety performance indicator is a basic management tool for manager decisions. Managers need the right information at the right time, which means they require reliable, relevant, sufficient, and effective data. Time is a hidden layer, extended in line with all business activities, decision making and performance assessment. This HSE performance measurement network should be developed among all managers in both static and dynamic concepts. No matter what kind of HSE management system is being implemented in a company, network communication in static concept requires each manager to have the right indicators for oneself at the right time. In a dynamic concept, this network should have the right Key Performance Indicator (KPI) to compile operational indicators into strategic drivers. On the other hand, the time period for data collection in a static concept should be adjusted within one timeline without overlapping or missing data. Blue time (BT) is the adjusted time (period of reporting) over a timeline that was developed by the author.

This research was conducted on an industrial scale, by interviewing 108 managers from different organizational levels. The managers were all from Iran and Malaysian companies. Managers were asked to select 5 of 45 HSE indicators presented to them, PI while they shared the favored time for performance data gathering and HSE data reporting. The following three objectives were explored: 1) empirical investigating the top five HSE performance indicators, 2) developing BT after time investigation for performance reporting, and 3) investigating the top HSE KPIs. Three complementary
studies were carried out to address two specifications of HSE communication in the network and to clarify the social benefit of the explored top HSE KPIs.

For the dynamic concept, total hazard potential (THP) was found as the top HSE KPI, which was a risk based indicator. THP is calculated based on the safety barriers, unsafe act (UA) and unsafe conditions (UC). Iranian Companies have primarily developed this KPI. BT is the optimized time period for data collection by each management level at the dynamic concept.

Contrary to the main objectives, the complementary objectives highlighted that there were significant differences among managers with different point of views. Other complementary studies, through statistical tests, clarified that a manager could not repackage the collected performance HSE reports (input data) and send these out directly. As there are no previous exploratory study on this them, the methodology of this research was exploratory with spiral approaches. This means that, after collecting data at each stage, the next stage proceeded by applying new filtering controls. The HSE communication network for the dynamic concept was constructed based on primary data in the statistical concept. Finally, the impacts of the findings were studied.
ABSTRAK

Meningkatkan kesedaran dalam aspek Kesihatan, Keselamatan dan Alam Sekitar (HSE) tidak memberi jaminan untuk melakukan perubahan di pelaksanaan HSE dalam amalan jika prestasinya tidak dilaporkan. Sebarang perubahan dalam budaya HSE perniagaan tidak akan berkesan jika amalan sewajarnya hanya dilaksanakan untuk membetulkan komponenannya pada jangka pendek.

Pengukuran prestasi HSE secara sistematik pada jangka pendek dan panjang memerlukan rekabentuk rangkaian HSE yang teliti demi komunikasi yang berkesan. Rangkaian pengukuran prestasi HSE ini perlu dibangunkan dengan baik di kalangan semua pengurus dalam kedua-dua konsep statik dan dinamik. Tidak kira apa jenis sistem pengurusan HSE dilaksanakan di sesebuah syarikat, rangkaian komunikasi dalam konsep statik memerlukan setiap pengurus untuk mempunyai petunjuk yang betul bagi dirinya di masa yang berketepatan.

Pada konsep dinamik, rangkaian ini harus mempunyai KPI yang betul untuk menghimpun petunjuk operatif menjadi pemandu strategik. Begitu juga, masa untuk pengumpulan data di konsep statik perlu disesuaikan untuk memenuhi keperluan rangkaian di konsep dinamik. Masa Biru (Blue Time) merupakan ungkapan baru yang dibangun oleh penerbit untuk menjawab keperluan-keperluan pada konsep dinamik.

Kajian ini dijalankan di skala industri melalui temubual dengan 108 pengurus dari peringkat organisasi yang berbeza di Iran dan Malaysia. Pengurus telah diminta untuk memilih 5 petunjuk HSE teratas daripada 45 petunjuk yang diberikan kepada mereka. Mereka juga diminta untuk berkongsi mengenai masa yang digemari dalam pengumpulan data prestasi dan pelaporan data HSE.

Tiga objektif telah ditumpukan termasuk: 1) menyiasat 5 petunjuk teratas prestasi HSE, 2) membangunkan “Blue Time” (BT) selepas penyiasatan masa untuk laporan prestasi dan 3) menyiasat petunjuk teratas prestasi utama (KPI) HSE. Tiga kajian
pelengkap dijalankan untuk menangani dua spesifikasi komunikasi HSE dalam rangkaian dan untuk menjelaskan manfaat sosial HSE KPI teratas. Pada konsep statik, 5 petunjuk teratas HSE yang disetkan pada setiap peringkat organisasi menekankan peringkat pengurusan yang berbeza yang memerlukan petunjuk prestasi yang berbeza. Bagaimanapun, petunjuk yang diperkenalkan mempunyai hubungan di antara satu sama lain. Pada konsep dinamik, Potensi Jumlah Bahaya (THP), diperkenalkan sebagai HSE KPI teratas yang merupakan petunjuk berasaskan risiko yakni yang dibina berasaskan Tindakan Tidak Selamat (UA) dan Keadaan Tidak Selamat (UC). KPI ini pada asalnya telah dibangunkan oleh syarikat di Iran. BT untuk tahap pengurusan yang berbeza telah dikira untuk menghubungkan pengurus pada konsep dinamik. Analisa statistik pelengkap menunjukkan terdapat perbezaan yang ketara di antara BT dalam beberapa aspek. Kajian pelengkap lain melalui ujian statistik menjelaskan bahawa pengurus tidak dapat mengolah semula laporan prestasi HSE yang dikumpul daripada anak-anak syarikat kerana mempunyai BT yang berbeza.

Melalui penemuan BT dan 5 petunjuk prestasi teratas bagi setiap paras pengurusan, dua peranan penting pada hubungan laporan pengurus dan penemuan KPI HSE teratas, penerbit telah merekabentuk satu rangkaian komunikasi prestasi. Perbincangan mengenai spesifikasi rangkaian ini pada kedua-dua konsep statik dan dinamik telah dilakukan manakala kajian pelengkap ketiga yang dijalankan telah menyediakan anggaran menggunakan KPI HSE teratas yang diselidiki. Dengan menggunakan kaedah Masa Interval Matrix (Time Interval Matrix) analisa secara teori telah memperlihatkan bahawa THP telah menyebabkan kenaikan sebanyak 6.4% dan 25% dalam bilangan syarikat yang bersandang kepada laporan prestasi HSE pada tempoh masa tiga dan enam bulan, masing-masing. Pembaikan ini telah memperlihatkan budaya HSE sebanyak 19% dan 65% dari tenaga kerja Malaysia terhadap tiga dan enam bulan tempoh laporan, masing-masing berbanding dengan suasana semasa.
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CHAPTER 1: INTRODUCTION

1.1 General Introduction

Health, safety, and environment (HSE) are three independent aspects of every activity, which interact internally. Companies are interested in managing all these aspects under the concept of HSE. Some companies integrate HSE with a security factor and follow HSSE\(^1\), while others simply add quality concern and make it HSEQ\(^2\). No matter what they call it (HSSE, SHE\(^3\), EHS\(^4\), or QHSE\(^5\)), it shows that a company is responsible for managing non-financial responsibilities in a sustainable and systematic manner. Managers in a business company try to manage both financial and non-financial aspects together both for the short and long terms\(^6\). Therefore, this detailed study on the concept of HSE was conducted.

Manager performance shapes organizational performance toward business success. Managers have different organizational ranks; however, they can be classified based on two different “point of views” (POV), in which some examine one discipline in detail, while others monitor multidisciplines. Tsukas (2005) defined micro POV managers as a group that makes a decision about a single assigned task. Managers with macro POV make decisions across different fields of operations. In fact, the micro perspective focuses on business managers in the field of operation or execution, while the macro perspective addresses the managers in the field of strategic planning and resource (Gholami, 2012).

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1 Health, Safety, Security, & Environment
2 Health, Safety, Environment, & Quality
3 Safety, Health, & Environment
4 Environment, Health, & Safety
5 Quality, Health, Safety, & Environment
6 Short term refers to the monthly and shorter cycles, while the long term is seasonal and above
Proper HSE performance at different POV inside a business organization should also be balanced and have links with other financial and non-financial aspects of business performance. This communication performance network should successfully help in conducting a business and would link to the business strategy; otherwise, it is simply a game with numbers.

Business success depends on the participation of all workers and stakeholders in sight of business objectives. This participation would be helpful if proper communication was established between them to change raw data to valuable and reliable information for management. This research was designed to help companies establish effective HSE performance communication networks, to help organize managerial performances at the lower levels, to enhance business performances.

Based on a pool of research, “Business Company” has already been suffering on how to make a decision and how to align financial and non-financial performances. Proper information is the basic essence for managerial decision making. Three important components of the right indicator, for the right manager, at the right time were introduced for effective communication in the business organization (Muntean & Surcel, 2013). The indicators should be reliable, sufficiently related, and metric, and may be integrated at different decision levels of the dynamic concept. Business is constructed based on the levels of managers that cooperate while each group carries their own special task.

Effective HSE performance measurement is still unclear to many business managers, while most of the examined management systems just provide a draft to managers; this is discussed in Chapter 2. According to the literature review, no previous work has been done on these concepts. Székely and Knirsch (2005) stated that many of the developed initiatives need more integration and empirical research in multidisciplinary fields.
A primary gap analysis in this research was identified through a critical literature review on business management, its objectives and strategy. Subsequently, the investigation explored the details of business management and its interaction with HSE management. The elements of an HSE management systems were then reviewed in the context of business objectives. Finally, business integrity and HSE implementation concepts were explored to determine the challenges in establishing the HSE performance network.

Proper HSE communication networks mean the right time and right indicator for the right manager. Primary data was collected through the literature review; the relationship between them was then examined using the research methodology, which is described in Chapter 3.

The HSE performance network has to be planned on two different concepts of static and dynamic. The static concept separately examines each management level with no interactions by others, whereas the dynamic concept examines the business communication network with ongoing interaction of managers. Two elements of “Time” and “Indicator” should be developed for both concepts. In the static concept, each managerial level just select the top five indicators in their opinion. They also have their own desired timetable for communication. In the dynamic network, two new phrases of BT and HSE KPI were defined to model the dynamic concept in comparison with the static concept.

The indicators in the static concept could not act in dynamic unless the indicator was metric. HSE KPI as a business strategic driver has the ability to do this function in dynamic concept. In fact, while performance indicators at each management level show the managerial desire at the static concept, HSE KPI should address how these indicators at different managerial levels may be connected to the performance of organization at the dynamic concept.
In this section, a general review highlights why these three concepts of time, indicators, and managerial levels are so important for the performance communication network in any business operation.

1.1.1 **HSE Concepts**

Health is very important in every work environment because its consequences are narrow (Nadakavukaren, 2000) and cannot be considered short term. However, it is easier for companies to neglect and difficult to prove health performance deficits. On the other hand, lack of attention to occupational health in an early stage would intensify workers’ troubles. Years later, this negligence would result in societies with an unhealthy older generation (Choi, 2009). Safety is important and a lack of safe conditions would lead to severe injuries or damage to the properties, resources, or time for delivery of services or products. Significantly, the risk level of safety in operations cannot be lower than the business risk level (Smith, 2011). Environmental topics are the other priority in view of firms’ managers that had a mixed interaction with safety and health. Companies may neglect environmental concepts if no powerful environmental authority exists (Sunstein, 2004) or if it does not make significant cost savings in the business operation. Environmental subjects have a significant impact in the long term in society; moreover, the government tries to set some initiatives on business tax for this (Barde, 1994). Managers are interested in hiding environmental impact unless they had predicted them in their primary cost estimation before (Jasch, 2003).

1.1.2 **HSE Liability**

Incidents not only affect companies but also confront societies with the impact of HSE challenges. For example, the chemical accident in Bhopal, India, owing to lack of safety requirements, resulted in 3000 deaths, 20,000 others being injured, and extended environmental and health effects (Leveson, 1995). Another recent environmental
accident at Deep-Water Horizon Drilling Unit at the Gulf of Mexico had an extensive HSE impact.

Business financial situations are sometimes considered important elements that have an impact on the HSE situation of companies and the incident occurrence. Insurance companies considered the wage-risk as a related factor for safety value or determination of insurance premium (Gegax, 1991). It means that the lower the workers’ income, the greater the safety risk of the job, if other factors, such as responsibility and job description, are constant. In the tragedy of Bhopal, the financial problem was one of the reasons that eliminated many of the HSE controls.

BP is an advanced and one of the pioneer companies in the Oil & Gas industry, with many projects and investments worldwide. They benefit from their own standards and tailor-made management system, good payment to their workers and many experts, technicians, and managers. However, this company had three disasters during the past ten years.

Companies try to learn from their past incidents; therefore, they spend a lot of their budget preventing re-occurrences of incidents or pollution spillage. Some may implement advanced risk control techniques or high safety systems; however, incidents may still re-occur. The occurrence of accidents enforces the Safety and Environmental authorities to set more advanced standards with more restricted criteria. This enforcement leads to increased budget estimation on projects owing to higher HSE levels. In fact, intensifying HSE requirements could lead to ineffective changes in practices after a while to prevent accidents; however, they result in an increase in the business financial risk. For example, the UK offshore regulatory doubled the number of environmental inspections on drilling rigs (Yeo, 2011) after the Deep-water accidents, and these requirements would affect the financial balance of projects and companies.
1.1.2.1 System or People

The HSE system is a combination of behavior base and systematic system management to comply with minimum regulatory enforcement in companies and to reach business objectives. It covers a wide area of business function, from design and planning to construction and installation, commissioning and operation, and maintenance, ending in closure. Risk management (as the core of HSE management system) must be integrated. While most of these stages were separately executed, business integrity needs the acceptable risk level to be balanced between all these stages.

Non-integrating risk management was the other reason for the Bhopal accident (Preble, 1997). Many techniques are implemented for a safe operation process at the design stage, especially in dangerous environments (e.g., pressure, temperature, level, and flow). Many standards are used at the design stage for safety and environmental aspects. Many processes controlling layers, alarm systems, safety instrumented systems, physical barriers, and emergency response equipment are being designed, constructed, and set up to eliminate narrow possibilities. Nevertheless, incidents are still occurring. In fact, any best and most redundant or advanced safety systems can be defeated by poor or conflicting management practices (Gruhn, 2006). Thus, HSE liability should be achieved by integrating system and people responsibility. While much research states the importance of these integrations, the way this process should be managed has not been integrated.

1.1.2.2 BP Management Experiences

Three years after the BP rig fire accident in 2002, another explosion at a Texas refinery occurred. In 2005, the incident investigation of the BP Texas refinery explosion
found a different root cause for the accidents: (i) poor HSE culture and (ii) lack of
difference between good and bad HSE behavior. CSB\(^7\), in its report, mentioned the HSE
management system at the BP Texas City refinery needs to be more effective and low
corporate safety culture leads to serious and long-standing deviations from good safety
practice (Holmstrom, 2006).

In 2010, another accident in the Gulf of Mexico by the Deep-water horizontal rig
under the management of BP led to a financial damage of more than US$41 billion,
beside decades of reclamation and adverse environmental impacts (Griggs, 2011).

Nguyen (Holmstrom, 2006), a lead incident investigator informed BP’s manager that,
“[i]f you don’t change your HSE Culture, the same accident may be happened again to
your company.”

Federal investigators hammered away at BP corporate culture and emphasized that
BP’s manager did not learn from the past, such as the explosions in 2002 and 2005. BP
managers, in response to the investigators, stated that they attempted to see that
everybody in their company feels that he/she can stop unsafe work; and that they are
attempting to improve the HSE culture. To this, Nguyen answered that, “[i]f everybody
was in charge and this accident happened, so it means that nobody was in charge!” (Lin
II, 2010)

Nguyen found that nobody had enough awareness of what was going to happen. He
emphasized that none of measure tools at the scene helped managers distinguish the real
safety gap.

BP’s manager knew that they needed to improve the HSE culture, but his knowledge
did not necessarily lead to its implementation in their practices. In fact, they also tried to
improve their culture as BP’s manager said, but improving HSE culture is not a job. It is

\(^7\) Chemical Safety Board
one of the outcomes of practicing HSE over a long period and should not be considered a barrier for incident prevention.

The other mentioned root cause of the BP accident was an improper balance between good and bad HSE behavior. For this reason, managers need to have effective measures in hand to manage the HSE performance of subsidiaries as well as managing his safety practices, progress, and the outcomes.

1.1.2.3 Managers’ Challenges

HSE experts ask managers to decrease the hazard level of its operation to the level of “As Low as Reasonable Practice” (ALARP), but experts could not tell managers how to integrate the discrete data for the entire business. Who is the responsible person for any probable incidents occurring while the hazard level was lower than the ALARP level? How can a manager know what HSE level their company stands on? This is another reason of the accident at BP; the manager supposed people did whatever they had to. In fact, managers need to have integrated performance network that provide reliable information by addressing its references at different organizational levels at and different time. Reporting the result-base indicator to managers would inform them about problem but could not point to the hazards surrounding them in the early stages.

Westwood (2008) argues that those who hide their mistakes are the worst offenders. He believes that no professional person should escape admitting his mistakes or try to hide them. However, the manager must ensure that the incident does not happen again. This is the other evidence cited by the author: how a manager understands and realizes the HSE situation to prevent the reoccurrence of an earlier accident. What advice is serious and what is unnecessary in the context of time and budget? In the real world, managers have no effective tools to control and monitor their HSE responsibilities. Thus, they must obey the separate perceptions of HSE experts and others with no
excuse. However, the incidents may happen again and land managers in trouble. This challenging situation motivates managers to transfer the responsibility to other groups.

An insurance company accepted the liability and compensated the cost on behalf of the company. Insurers set an insurance premium for companies for specific jobs. The way they measure the premium, the process of supporting the liability and its impact on safety are debatable. The insurer determines the insurance rate based on the past lagging records. Although they audit the company (to estimate how powerful safety management system is), they concentrate on the result base indicators. The ratio of incidents in most cases was determined and followed by the insurer to consider a safety margin. Asking for results-based indicators makes companies more sensitive to this group of indicators, instead of being attentive to their tailor-made proactive indicators. As insurance companies accept liability and compensate the cost on behalf of companies, almost all managers feel relief and neglect the HSE commitment. However, there are many reasons for not purchasing the full insurance coverage and this is a critical point. Besides, companies are forced by the insurer to meet all HSE regulations and governmental HSE legislations for criminal purposes. This means managers should conserve all HSE requirements themselves. The insurer just accepts the liability of unpredicted incidents while every requirement remains unchanged in place. Social security insurance is also supported for managers, only for lapses (Werther, 2005). No matter who supports companies after the incident for direct financial compensation, companies are held responsible for safe jobs by the regulatory authorities. For example, the ILO convention 55 provides general and minimum responsibilities for safe management and worker’s occupational health for business managers, internationally. In this situation, the company again is responsible for all its HSE performances and could be liable to HSE rules and regulations.
Lack of proper HSE measures put managers in a weak position to defend themselves in any challenges with insurers or inspectors.

1.1.3 HSE Participation and Commitment

1.1.3.1 Benefit of Participation

Participation and accountability of all workers in HSE would empower companies in terms of human resources (Svensen, 2007). Kotter (1992) identified a strong correlation between culture and organizational performance, as shown in Table 1.1. Global companies manage entire HSE requirements by enhancing the HSE culture as a key to raise their profit (Hudson, 2007). This research is designed to develop a proper HSE communication network. HSE performances need to be measured properly, then communicated in the business organization. By enhancing communication culture, the enterprise would then move forward (Kotter, 2008). Kotter et al. (1992) showed how adaptive organizational culture creates high-performing firms compared with non-adaptive culture. More than a 680% increase in revenue growth was the outcome of companies who benefited from adaptive culture in comparison with 166% growth for the companies who did not manage their culture as well. The difference in the net income growth for companies with enhancing culture than non-enhanced culture was 765% versus 1%, respectively.

Table 1.1: Organizational culture versus Enterprises’ financial benefits (Kotter & Heskett, 1992)

<table>
<thead>
<tr>
<th>Measure Indicator</th>
<th>The average percentages in companies with Performance Enhancing Culture (n = 12)</th>
<th>The average percentages in companies without Performance Enhancing Culture (n = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue Growth</td>
<td>682</td>
<td>166</td>
</tr>
<tr>
<td>Employment Growth</td>
<td>282</td>
<td>36</td>
</tr>
<tr>
<td>Stock Price Growth</td>
<td>901</td>
<td>74</td>
</tr>
<tr>
<td>Net Income Growth</td>
<td>756</td>
<td>1</td>
</tr>
</tbody>
</table>
Kotter et al. (1992) highlighted the importance of gathering the attention of all employees to care for themselves and for the business, in a two-way communication.

Another important outcome of Kotter’s research was that leadership should be demanded from all management levels in a company. Thus, HSE performance should be conducted by all management levels of different business departments. HSE communication network conduct managers should be clarified to evaluate their own HSE performances as well as steer the performance of their subsidiaries.

The importance of engaging all managers in HSE was emphasized by other researchers; however, the way they measure HSE management performances is doubtful. For example, the gap analysis conducted in 2008 by Gualardo through few different companies highlighted that line manager participation in HSE had a significant effect in improving the HSE performance of companies. Planek (1983), in his research, on behalf of safety professionals, stated that three management levels had an important role in the safety performance of companies if they actively participated in HSE. These management levels were senior management, middle managers, and supervisors. HSE experts believed that the current measurement of HSE performances were not measureable in practice as the other concept of business (e.g., throughput rate) (Gualardo, 2008).

1.1.3.2 Commitment Growth

Managers are likely interested in jobs that can demonstrate their positive role (Latino, 2011). Clarifications of how a manager performs in terms of HSE for his/her upper manager will motivate him/her to improve HSE performances actively. Weak HSE communications would decrease HSE commitment at both parties (senders and receivers) in the HSE performance network. However, the impact of upper management on subsidiaries is higher than the impact of subsidiaries on the upper level. In fact,
lower managers would miss their attention to the subjects not actively searched by their upper managers.

Balancing how managers are supposed to perform and what managers are expected to receive will build their attention, influencing their commitment. Safety management systems introduce top manager leadership or commitment as the basic and essential foundation for system implementation (Marsh, 1998; Székely & Knirsch, 2005). Managers allocate safety resources and support safety organization in businesses by their decisions. However, the commitment is unsustainable if managers miss their desire for safety systems. The unwillingness of HSE occurs if managers cannot present their performances positively or if there is no desire at system to distinguish good performance over the short- and long term.

1.1.3.3 HSE Budget Allocation

Performance reports in HSE fields always represent a narration of some practices, such as story telling with pictures and graphs. However, it should provide strong evidence of what managers have done based on their decisions in terms of HSE. Proper information will conduct managers to rectify its direction and its speed to achieve his/her goals. Reporting expired data or unrelated indicators would hinder managers in live decision making.

Managers were invited to HSE improvement continuously by HSE authorities. How could a manager realize the level of investment essential in the current business situation? What is the risk level and which one of the requested safety resources is prioritized other than business requirements? If a manager decided to increase or decrease the safety investment, how would the system provide useful information from the raw data to support this need in quantitative manner? How would the upper manager be informed of the right or wrong decision taken by subsidiaries on HSE allocation in the short- and long term?
1.1.4 **Time Importance**

1.1.4.1 **Time Usage**

HSE performance reporting is an essential part of a management system that might lead to proper manager decisions. Regardless of the subject of measurement, prominent time for reporting, and the frequency of measurements are two important time elements in effective decisions.

As mentioned in the accident of BP, 2010, “time” is the key element that has a critical role in HSE planning and business expenses. Time is a factor that affects the number of collected data. Thus, it will influence the reliability or validity of decisions. It would also be a framework through which to integrate the safety with other business targets and performances. Time would be a good foundation for comparison and benchmarking; however, this is an auxiliary benefit of time.

The other important concept of time would be in setting a speed limit for functioning. Time could affect the norm setting in safe operations or HSE inspection that directly affects business expenses (e.g., offshore inspections).

1.1.4.2 **Time Integrating**

Integrating performance reports within the organization network needs to consider the time dimension. Integration of reports within different time lines or with different time content without prior adjustment would lead to data mixing and to meaningless results. According to Zaheer (1999), the time specifications would be changed by changing the firms’ level to industrial level and vice versa. Many social theories were discussed regarding the time and emphasis on decision making (Maule, 1993).

1.1.4.3 **Time Component**

Time might be evaluated at different concepts in HSE management. Sometimes, it emphasizes the sequences of time and demonstrates the “time schedule.” Since a project initiates at design stage and continues to the other stages until termination of
operation, time is an important element. The time schedule in projects covers a wide range of activities, including preparation of HSE needs and its priorities.

“Frequency of time” is another time concept emphasizing the Time Interval of an operation or reporting. Designing, planning, and maintaining HSE control systems in instruments, alarming or test of critical performance should be done at different time periods. In a similar manner, the monitoring of HSE performances should be conducted at proper time intervals. Time frequency on a daily basis would lead the reporting moved on the timeline; however, larger time intervals lead to more discrete reports.

The third concept of time in research is called “response time.” It points out how fast a decision is made on a specific operation in practice or how much time it took for communications or tasks arrangement, especially in emergency situations. For example, how many minutes it took for a response team to reach the scene.

The last concept of time in HSE management is “life cycles,” generally used for technical analysis and evaluation at longer periods. It covers a process, equipment, contract or many other subjects from the time it starts until the time it terminates. It has different usage, such as estimation of the environmental impact of a product or the time needed for replacing a spare part because of safety. In HSE, it is also used for risk control, cost estimation of environmental damages or environmental resource management, etc.

The majority of these time concepts have been studied by researchers. For example, time in sight of emergency decision was studied by Benbasat and Dexter (1986) and Ahituv (1998). Some other groups studied how fast a manager could take a prompt decision (Coiera, 2006; Flin, 1996; Ward, 2011). Life cycle was studied in many papers. In management and quality fields, frequency of time has been studied in other research for regular HSE inspections and audits. However, there is no previous study to link the time content of indicators and time cycles of reporting.
The explosion on the Deep-Water Horizon rig, on April 2010, led to the death of 11 workers, a huge amount of oil spillage and cost above US$42 billion (Griggs, 2011). BP had two important explosions in their past operation before the recent accident in 2010. The root cause of the accidents was the same, which was called a weak HSE culture by Nguyen\(^8\) (Holmstrom, 2006). A lack of accidents over time does not guarantee any further accidents.

The environmental review after the accident was conducted by DECC\(^9\) in the UK, who announced that the environmental requirement is fit for the purpose (Yeo, 2011). However, the inspection rate was doubled and the insurance requirements revised. In fact, this accident doubled the rate of inspections and raised costs. This means that, rather than attending to the HSE culture, technical items and managing the HSE culture, they doubled required safety inspections. In fact, time is a fundamental element in any HSE management, communication and performance management.

In contrast to past research on time, this research does not focus on emergencies or monitor the impact of time on emergency decision making. Moreover, this research is not interested in developing other HSE indicators. This research is designed to determine the right time needed by each management. By balancing discrete time cycles, manager reports could then easily be integrated or interpreted from a level to other organizational levels over the same timeline. In fact, within this approach, managers will understand the time that they were supposed to communicate with others in the business network.

\(^8\) BP lead investigator

\(^9\) Department of Energy and Climate Change
1.1.5 **Business Social Impact**

Social impact is the other important scope addressed in this research. In Malaysia, more than 97% of establishments are SMEs (SMECorp, 2011), meaning that just a simple movement in this group will create a wide impact on their environment and society overall. This subject will be discussed further in Chapter 2. Rawlinson (2005) showed that, if the managers in SMEs were interested in HSE, HSE performances would dramatically improve (Rowlinson, 2005). In Malaysia, 74 of 97 percent of Malaysian employment is under the micro company with less than five employees. 20% has been working for a company with a population of between five and 20 workers and nearly 3% with population of 20 to 50 full-time workers. Beside this, 89% of Malaysian SMEs are working in service sectors. According to Razak (2011), this rate shows a dynamic work environment and less opportunity for routine inspections. The Malaysian statistics emphasized that many of the operational responsibilities in large companies were carried out by SMEs and their contractors. High reliability of HSE culture in subsidiaries will improve the HSE culture of its clients and vice versa (Škerlavaj, 2007).

1.2 **Problem Statement**

A high level of HSE culture does not necessarily mean that companies employ a large HSE organization (Hudson, Parker, Benson, Graaf, & Gerard, 2002). Moreover, the ALARP level prohibits companies from spending many resources while the company encounters challenges. Proper HSE culture would be helpful to reduce the work pressure and improve the efficiency by engaging all employees (Palassis, Schulte, & Geraci, 2006). If any employee performed one’s own HSE responsibility on their task, the business HSE culture would continuously grow with minimum pressure on subsidiaries. Reaching this HSE culture level requires businesses to set up proper performance communication networks which show the progress of different managers associated with their responsibilities. Establishing an HSE performance network in a
business is the main concern of this research. It would increase HSE commitment at all management layers, while participation of all managers would lead to the success of the business. The questions in this research aimed to establish an effective HSE performance network by covering two different concepts, static and dynamic concepts.

Within the static concept, the following were the two main questions:

1. Which subjects of HSE performance indicators are focused on more by managers in companies?
2. How often should managers review one’s or subsidiaries HSE performance?

Within the dynamic concept, the following were the two main questions:

3. Which of the current HSE performance indicators could be the top HSE KPIs in a company?
4. Which time period can be set between managers for performance reporting in a dynamic network?

Beside the above questions, two complementary questions were also asked:

5. What is the proposed organizational map for the HSE performance network? How do managers link their selected HSE performance indicators?
6. How many Malaysian businesses have a reliable HSE performance report while they utilize the lagging safety indicators requested by the safety authorities? How much social improvement can be achieved by substituting the top HSE KPI with the current lagging indicators?

1.3 Objective of the Study

1.3.1 Research Main Objectives

This research was designed to help companies empower HSE commitment by establishing an effective HSE performance network. The effective HSE performance network needs correctly specified network components, while managers are the basic
components of this network. The two elements of time and performance indicators should be investigated in empirical research at each managerial level.

1- Empirical research should investigate the top five HSE indicators at different management levels in business companies by answering the question below:

What are the top five HSE indicators for each management level?

*Why top five?* Based on research by IAEA members for overall safety performance management synthesized a set of seven performance indicators, four of which were technically nuclear subjects and three indicators for safety management. As this research examined three scopes of safety, including health and environmental subjects as well as just safety, five selections of indicators were considered.

*Why HSE?* Health, Safety, and Environment are the three symbols of the social-environmental aspect of business performance required for a business sustainability approach.

2- The following question must be answered when developing the BT Interval for different management levels in business companies:

What is the BT for each management level?

*Why Time?* Time is introduced as an embedded dimension in any decision making.

*Why organizational management levels?* The progress of the business depends on the participation of all managers.

3- Empirical investigation of the top HSE KPI inside a business company must be conducted by answering the following question:

Which of the top five performance indicators could be the top business HSE KPI?

*Why Strategic Driver?* HSE KPI should be the strategic driver in comparison with the other type of performance indicator (result base, operational indicators). It should be selected based on the interest at macro perspective managers. Besides, it should provide a summary of the performance of operational drivers for the upper organizational levels.
Why Top KPI? The organization is looking for a limited number of indicators with interested from most decision makers.

Figure 1.1: Research objectives covering both the static and dynamic concepts

1.3.2 Research Complementary Objectives

Three complementary studies were designed to provide additional information to establish the performance network. Two of them provide information on how to link different managerial levels. The third aimed to determine the social impact of this research in Malaysian industrial communities.

The complementary objectives are as follows:

4- Shall the time period for HSE data gathering and HSE data reporting be similar at different managerial levels?

5- Do changes in managerial POV lead to significant change at the requested time of reporting?

10 Numbering is in continuation of research objectives
The last complementary study was designed to study the social impact of the top HSE KPI.

6- What percentage of Malaysian companies would benefit by having a reliable performance report on average, a seasonal periodic report, if they used the top HSE KPI?

1.4 Research Scope

Empirical investigation of two important factors, indicator and time, was conducted by analyzing managers’ desire at different organizational levels. Improving HSE commitment through managers’ desire was studied. In information technology research, Barki (1985), in his study on 32 decision support systems (DSS) found that “user attitude” is one of the dominant attributions in implementing successful decision supporting systems. This outcome implies that managers’ desire would be the dominant attribution for managers’ decision. Desire of managers in implementing and conducting different activities inside the company has been highlighted by other researchers (Hutchinson, 1995; Mazzarol, 2003; Perren, 1999). In SMEs, the personal desire of top managers has more influence on HSE performances. Mazzarol (2003) stated that the manager’s personality is dominant rather than the systems to drive SMEs. Renwick (2003) mentioned that the manager’s desire has a positive impact on performance. Besides, an HSE communication network would increase managerial collaboration and enhance commitment.

The scope of research was companies in developing countries. Managers in this research are limited to the business company, its subsidiaries and contractors. It means regulation bodies or managers with regulatory perspectives were not included in this research. The invited companies were all from Malaysia and Iran and should have an Integrated Management System (IMS) with at least one external audit revalidation. The research samples covered both large enterprises and SMEs. The type of operation and
where the company worked were assumed to have no effects in this research, because the experience of management may have varied according to past working experiences. However, organizational levels and working experiences are very important. Type of operation was unimportant as this research concentrated on managerial ranks and not on managerial professional duties.

This research did not aim to develop new HSE indicators by itself. Input from the research investigation covered a wide range of HSE indicators currently used by participating companies or other well-known organizations. The subject of indicators was used as a reference for investigation rather a technical definition of indicators.

This research focused on the HSE performances of subjects. Thus, it was not aimed at other business non-financial attributions, or HSSE and HSEQ concepts.

The number of working days may vary depending on the selected calendar by companies. However, any changes in the number of working days during the monthly period were ignored. To prevent errors in time integration, all invited companies should have full week working schedule (seven working days per week).

1.5 Research Chapter Organization

Chapter 1 comprises the introduction, describing the objectives, concepts, frame, and problem statements of the research. Chapter 2 covers the literature review through six main sections to highlight the integrated movement from the overall perspective, to reach the objective details. The first part of this chapter started from enterprise management in society and what they need. The discussion narrows to the management systems that might be employed in companies for this purpose. Business strategy, objectives, subcontracting, business risks, and stakeholder integration were explored in the first section.

In the second section of chapter two, the outcomes of some systematic performance management systems in theory and practice are explained, if used for HSE.
attribution, HSE slavery, and HSE culture are three outstanding HSE contributions to business management in companies. Different HSE management systems that might be employed in companies were explored, while three of them are critically reviewed, including: Behavior Base Safety (BBS), Voluntary Protection Program (VPP), and ANSI Z10\textsuperscript{11}. Moreover, two strategies to implement the HSE management system were criticized by the authors: the HSE Agile Management System and Integrated Management System (IMS).

The third section of Chapter 2 concentrates on performance reporting and its measurement. The literature review in this section starts by defining performance report terminology and the history of HSE reports. The author then explores different safety measurement systems within three groups: a) partial modeling systems for safety performance, b) complete modeling systems for safety performance, and c) risk-based performance systems. The use of many common performance management tools are explained if used in HSE, including TQM, Six Sigma, audit system, benchmarking, business scorecard, HSE culture measurement, OSHA recordable case, overall safety performances, probabilistic safety assessment (PSA), risk management pass, and total hazard potential.

Section four and five of chapter 2 covered two important elements in this research: HSE Indicators and Time. Section four concentrates solely on HSE indicators through indicator classifications, their hierarchy, HSE indicators in Malaysia, and common mistakes on indicator reporting. The fifth section provides a close examination of time elements in business communication networks. The Time Interval Matrix is developed

\textsuperscript{11} The new American management systems standard in occupational safety and health
in this section to test the time reliability of performance reports. Section six concentrates on HSE conditions in Malaysia.

Chapter 3 addressed the methodology of this research, which started by reviewing the research objectives and three complementary subjects. It was then extended by describing the sample population selection. Moreover, the different techniques employed for score calculation, statistical analysis, and methodology power control are discussed in chapter three. Finally, all adapted indicators from companies were shortlisted and grouped at related subjects and ID.

Chapter 4 presents the results of empirical investigations in seven sections. The first section presents the specification of participants and sample populations. The second section explains the extracted data from interviews, including the indicator score for each indicator subject. HSE scores are calculated for management POV. The top five HSE indicators at each management level are presented. The third section in this chapter was allocated to the results of the investigation on Time, to develop BT. BT for performance reporting is calculated for each management level after discussing time elements. The fourth section includes the top five HSE performance indicators for each managerial level, while discussion had done with desire of managers. The fifth section of chapter 4 is allocated to finding the top HSE KPI and its score calculations. Finally, three complementary studies are discussed in the sixth section. It also included statistical hypothesis analyses.

Chapter 5 discusses on research findings on the business HSE performance network. It includes the review of the network specifications at the static concept for each management level, expanding on two business perspectives. The HSE performance network is mapped for the dynamic concept through the link between the indicators and managers, including the link of the top manager of large enterprises and SME managers.
This investigation is conducted using the research findings (selected indicators) as evidence to establish the HSE performance network in business companies.

Chapter 6 presents the conclusions of the research on both the static and dynamic concepts and a summary of the communication pattern among different management layers over their top five selections.
CHAPTER 2: LITERATURE REVIEW

2.1 Enterprises and Business Management

This section provides a review of some important components of business management, including business strategy, objectives, manager commitment, and risk management. The literature review highlights the importance of these components for business success. Besides, it prepares evidences to declare the inevitable role of HSE in business management components.

2.1.1 Business Strategy

According to Dawar (2013), business strategy in today’s marketing focused on how companies influence customers to increase its brand beyond advertisement. They penetrate the minds of their customers through environmental activities, social contribution, or providing special services to their stakeholders. Dawar explained from the market perspective, how a 700% increase in the profit of a company could happen by attending to stakeholder benefits. Nwagbara and Reid (2013) stated the need to move toward sustainable strategy by companies. Corporate Social Responsibilities (CSR) is a new developed system to achieve this goal pointed to the social part of business outcomes.

Business sustainability is the other system to move companies toward sustainability strategies. It is constructed on balances among economic efficiency, social equity, and environmental performance in company’s practices (Labuschagne, 2005).

2.1.1.1 Corporate Social Responsibility vs Corporate Sustainability

The strategy will affect business activities. Resource organizing, distribution of responsibilities, and circle of decision between managers have been done in line with the business strategy. Tactics are a working strategy that an internal manager set for himself as an adaptation of business strategy. Business ineffectiveness was reported if
tactics (working strategy) is misaligned with business strategy. For example, setting IT strategy apart from the business strategy introduced as a barrier to business success (Atafar, 2011). When business strategy set by a top manager on sustainability as an example, all running tactics at working levels should be tuned up with this approach. This adjustment was not limited to HSE department, but also covered all commercial, Human Resource, manufacturing, maintenance, operations, IT, and all other departments.

Different management systems have been developed for companies to justify their operational process toward specific strategy directly. CSR or CS is an auxiliary strategy used for advertising rather than business management. In fact, business companies need management systems that support their decision on changing their strategy.

CSR is a strategy to meet the social outcome of business activities over the business stakeholders. CSR conducts business to be economically profitable, law abiding, ethical and socially supportive (Carroll, 1991). Ofori and Hinson (2007) carried out review on different CSR strategies, stating that companies should go beyond maximizing profit and should be responsible to a broad range of stakeholders, including employees, customers, community, and the environment. Many companies repackage their HSE performances under CSR strategies. The author believed that the HSE performance could be repackaged to illustrate the CSR outcomes; however, having CSR does not guarantee the company has HSE. The reason is the HSE report should develop in details in the short term and in a continuous manner, while CSR performance is a long term performance. Moreover, the HSE report is mainly obligatory over the business activities; CSR performance is not obligatory. HSE in comparison with CSR, affects both social and environmental concepts.

Corporate sustainability (CS) is the other new developed concept that emphasizes the long term balance of economic, social, and environment in connection. Van Marrewijk
(2003) provides an overview of both CSR and CS debated and concludes that they are two sides of a coin. While CSR operates cross-sectionally, to connect organizations and communities at the moment, CS stresses on long term relationships among these elements. Steurer, Langer, Konrad and Martinuzzi (2005) expressed CS as a definition between current and future generations. However, CS in comparison with HSE just pointed to few important items in the long term. In contrast, HSE is looking for short- and long term solutions to cover HSE elements continuously. As having a clear strategy is one of the most important steps in justifying business activities, so two related strategies are discussed.

2.1.1.2 ERP and Agile Management

Implementing the desired business strategy needs a proper communication system employed in a company. Enterprise resource planning (ERP) was an emerged communication approach in the past few decades in business strategy and its information management (Westwood, 2008). It drives companies to have effective management through raising the business information integrity (Olivier, 2009). A wide range of data with different dimensions are integrated and managed in a live manner to guarantee business success in a challenging environment. In fact, ERP provides a company with a real-time decision system by integrating the different information they may need from different resources. Constructing this tool is not easy and requires extensive software development and maintenance. Different technical and engineering problems are reported for ERP in large organizations in system implementation or maintenance; however, this approach is highly advised for SMEs by the researcher (Laukkanen, 2007). Stakeholders are introduced as an important part of business resources in ERP which affect business success (Al-Khalifa, 2007). Broad institutional, organizational, and individual levels are participating in the ERP. Each provides information and contributes to the decision-making process. Information transferred in
coherent links between resources, performances, and responsibilities (Kennedy-Glans, 2010). However, proper decisions need reliable and proper information. Nah (1997) stated that ERP performances should be monitored and be evaluated continuously to prevent incorrect decisions. In fact, ERP is a wide network of communication and performance measurement in dynamic concept.

While different management approaches are adopted by enterprises for their business management, the literature review highlighted the importance of the new approach in business management called agility. The tendency of companies to adopt changes in the business environment and market drives manufactures and companies to agility (Yusuf, Sarhadi, & Gunasekaran, 1999). Agility was defined recently as the powerful and dynamic strategy in confronting changes by different researches (Yusuf et al., 1999). It stresses business ability for adaptability and flexibility in arranging objectives. The history of agility dates back to leadership agility in the past three decades on consultations for business management (Joiner & Josephs, 2006). Agile management conducts a company on effective implementation of a plan to balance needs and resources (Yu, 2005).

Regardless of what strategy might set for a company, evaluating the two most common business management strategies highlights that enterprising managers seek two approaches in their management: 1 extensive integrity through documentation, clear responsibilities assignment, and continuous resource planning (ERP) and 2 - flexible trusted organization in confronting different needs for rapid changes (Agile System).

Proper implemented ERP would provide a more effective decision-making tool; however, it needs more time for installation. An agile system, however, would provide a higher capability in organization for prompt action and higher flexibility, but also with lower effectiveness. The author believes that both approaches are essential for a large organization. To overcome the challenges at the front line of construction, greater
flexibility or employing the agile approach is required, while ERP would be helpful at the top organization level or at the process units. In the next section, the discussion concentrates on how business objectives might be set in companies and how these address HSE.

2.1.2 **Business Objective**

Business objectives are the other important component of business management, which may differ from companies to companies. Business objectives are defined in companies in a wide range from ethical and humanity objectives to maximizing wealth, or from social to environmental objectives, depending on the business strategy. Some other objectives may include risk management objectives, value oriented or harmony objectives, or information objectives.

Worker participation to reach objectives is a key to effective management. According to the firm theory (Kallianiotis, 2003), business suffers if the agent (CEO) is not part of shareholders and does not have stocks. The maximum part of the business is used for their own welfare such as luxurious offices, cars, business class transfers, et cetera. To increase business efficiency and profit, it is necessary for a company to select a CEO from one of the major stockholders (Kallianiotis, 2003). Similar behavior is proposed inside the company for internal managers and workers at lower organizational levels.

Objectives cascade and scale down from the business level to the working levels and make working objectives. Managers may have their own proactive or reactive approaches. Activity, resource, and subsidiary output must be consistent with business priorities. Internal managerial attention to working and business objectives would raise the accountability of workers to business objectives by respecting the working objectives (Atafar, 2011). However, justification of working objectives with business objectives is an important responsibility of a manager that should be done by
considering the upper managers’ request and the reality of the situation. If objectives were set based on the desire of upper managers without attention to the probability of its achievement in practice, then working objectives would change to fragile objectives. This approach could not be sustainable if participants did not actively support that, or if the working objectives did not fulfill the business objectives in sight of the business strategy (Khalili, Hossain, Jamshid, & Alborzi, 2013).

By changing the situation or passing time, the objectives need to include updating and revising. Ioannis (2013) recommended that business objectives should be set based on proper business market, finance and operational information, and its sustainability, especially considering its risk. Therefore, managers have to be apprised of changes in HSE performances of subsidiaries and themselves and their risks for this justification.

The objectives must be implemented by managers. Enterprises may publish different policy, goals, and objectives on their working environment; however, they are the advertisement windows until managers turn them into practices. The term “goal” is used instead of objectives, while both represent the same concept (Bassey et al., 2012). In normal situations, managers arrange their resources and organizations to reach their objectives. Managers are able to tolerate work pressure by balancing their resources. Adding any new responsibility to the daily tasks of a manager, uses the manager’s time and resources. However, a manager has limited capacity and cannot exceed that by accepting a wide range of responsibilities. Managers should manage and monitor all assigned responsibilities and deal with its challenges. Therefore, the company could add different goals to their business, but it would not turn into practice unless its resources are allocated and its progress is monitored as part of the manager’s daily responsibilities.

In sum, four issues should be considered when setting up objectives of a company with proactive strategies:
1- Business objectives should be consistent with the business strategy while working objectives should actively support business objectives.

2- The right of all related stakeholders, including workers and customers, should be considered in objective definition. This makes them actively participate with the business to achieve its objectives.

3- Objectives should be reviewed and revised by changing the business and working strategies at management layers. They should provide background information on their progress and the risks encountered before any objectives are revised.

4- Adding any new objectives requires the company to provide its resources for that and to justify the primary organizational capacity to bear with the changes. Otherwise, adding the new objective will just be an advertisement window for a company.

2.1.3 Business Commitment

After setting up proper strategies, objectives, and tactics, the idea should come into practice. Resources should be assigned, the performance should be recorded, and the recommendation for decision improvement should be given based on overall risk. Manager commitment implies the priority given by managers for the objectives.

Commitment is traditionally defined by Mowday (1979) as the willingness to exert effort on its behalf and to believe in the accepted values or goals of an organization. However, in the current business era of downsizing and flexibility, many people prefer to show that they are just motivated. The researcher introduced commitment by a challenging approach, being highly proactive, and innovations to reach the set goal. For its success, a business seeks highly motivated and capable employees and managers, while they need communication to show their awareness and feelings. Communication and responses to responsibilities in verbal, written, and behavioral form will influence
the commitment (Memari, Mahdieh, & Marnani, 2013). By increasing positive collaboration between managers, the trust and commitment between them will be increased (Mavondo & Rodrigo, 2001).

2.1.4 Business Risk Management

Risk and risk management are the other important elements in enterprise management in confronting unreliable or unpredicted situations. The risk idea used in a wide range of decision making, including finance, economics, strategic management, supply chain, social and environmental fields. Risk accumulation and its analysis require risks being added or subtracted from layer to layer and from fields to fields or time to time. Risk aggregation could be essential between different subjects at different organizational levels over the timeline. Therefore, managers need properly to report their risks with proper specifications to prevent mistakes within aggregation at the upper organizing level.

2.1.4.1 Risk Concepts at Business Company

Business risk is defined through different concepts. The financial risk of pricing and anticipating the potential move of the markets and credits are a major concern of financial institutions (Bouchaud & Potters, 2000). Different models may be used for risk assessment. In general, financial risk is the outcome of time series analysis of value at risk raised from other risks such as market, liquidity, operational, credit, and business risks (Christoffersen, 2011).

Operational risk is the other important type of risk influenced by business human resources, technology, administration, and work environment. Changes in operational risk are so broad that part of its weakness is transmitted to third parties or self-insurance. Operational risk affects business profitably and efficiency and is almost not hedged by insurance. Exposure to this risk could lead to very little financial return and bearing with a higher risk of loss in the short term. HSE risk management would help
companies measure operational risk in terms of analyzing operational faults and dangerous situations. Moreover, it can provide a way for understanding a part of social risks, which could not be transferred to third parties. Operational risk could also affect credit risk through jurisdiction for non-complying.

Business risk is an internal risk of establishment based on its business plan and viability of its cycles. Changes in technology, social partnership, or competitive behavior will influence this risk. It should be noted that the margin of these definitions have overlapped and blurred between different types of risks.

2.1.4.2 Risk Integrity

Three concepts must be supported for business sustainability: financial, social, and environmental risks. Business overall risk must aggregate the outcome of these three concepts, consistent with operational risk. Financial risk is one of the business risk concepts that deals with decisions about economic value in a firm (Hampton, 2011). The HSE risk concept is the other business risk that examines the social and environmental risk of operation. However, operation and financial risks and HSE risk interact with each other. Statzer (1999) explains how a company with negative cash flow can gain profits by having proper social and environmental risk management operations.

HSE risk could be increased by workers, equipment, process, work environment, and operational process. Sometimes, a company spends much of their budget during the planning and construction stage, but they leave many of their investments behind at the operational stage. For example, in a process design, they order a high safety integrity level (SIL) of the process (SIL level 3 or 4). However, many sensors are lost owing to poor attention in the maintenance stage, imposing higher levels of risk on the whole process (e.g., Bhopal tragedy). Beside changes in the operational situation, companies may be asked to add different new barriers to their installation. For example, changes in
security risks owing to terrorist attacks or internal crime by workers should be added to
the priorities in a dangerous operation (Lee, 2002). Different techniques and standards
for HSE risk management were addressed by ISO 31000, providing a framework for
managing business risk.

2.2 Business Management and HSE

In this chapter, HSE gaps and failures through management components are
explored. The size of a company influences which type of business management and the
HSE management system it implements.

2.2.1 Large Company or SME

List of top companies or high ranked business in different areas or industrial sectors
are full of large enterprises, in which they publish a CSR, HSE, or CS annual report.
Noci (1999) confirmed that many studies in HSE performance usually focus on large
corporations and highlighted that researchers neglect SMEs. Eakins (1992) highlighted
that small businesses are more inadequate than larger organizations in implementing of
HSE program for themselves. This challenge was not limited to developed or
developing countries; however, worse situations in developing countries are being
addressed by researchers (Kheni, 2010). The higher safety performance in a large
enterprise than SMEs was also asserted with researches in Denmark (Sorensen, 2007)
and Australia (Brooks, 2008).

On the other hand, Small and Medium Enterprises (SMEs) contribute greatly to the
social and economic situation. A majority of tough activities transfer from large
enterprises to SMES through subcontractors. The outsourcing of dangerous activities of
the main company toward its contractor and SMEs was also stated by researchers
(Harrison, 1997; Sorensen, 2007). Inadequate SME research causes a situation in which
working environments are higher risk and their activities have a greater social and
environmental impact (Biondi, 2000; Bruijn, 2000; Friedman, 2000; Jenkins, 2009).
Hillary (2004) highlighted the environmental impact of SMEs as outweighing larger firms. He said that the health and safety responsibilities in these groups are narrow and rare, while almost all have concerns regarding their profits. Moreover, he believed that lack of resources is the main reason that propels SMEs toward poor safety management systems.

McVittie (1997) found that the rate of injury frequency varies in reverse of the size of firms: smaller companies have a higher rate of injuries. The higher rate of accidents in SMEs also addresses the lower HSE culture in this group and more social and environmental crises in communities. Other research done by Helen on SMEs in the construction industry asserted that workers in SMEs encounter a higher risk of danger in the field. Besides, she stated that they have not been consulted by their clients on their safety decisions, which affects their tasks (Lingard, 2001).

2.2.2 HSE Attribution

Aksorn (2008) studied 16 critical factors that impact safety programs in the construction industry. 80 medium (50 to 200 workers) and large (more than 200 workers) companies in Taiwan were studied. The finding stated that management support is the first and most important gap in these companies of the 16 studied factors. The next most important factors were safety knowledge, clear and realistic goals, effective enforcement schemes, and teamwork.

He expressed that workers in a company almost have enough knowledge about what to do with safety and how to do a safe job; however, they do not have enough motivation to follow what they believed in (Aksorn, 2008). In other research, conducted on offshore installation managers in the UK with participation of more than 200 of managers, where managers declared that they were aware of the best practice of safety and safety leadership, they did not always take the necessary actions (O’Dea, 2001). Zohar (2002) found that line managers and supervisors have a great effect on the safety
behavior of subsidiaries if they are involved in the weekly feedback of safety performance.

All of the above statements highlighted the importance of having an effective HSE management system, effective HSE objectives, and the essence of involving HSE within the main business objectives in both large and SMEs. Following the role of HSE commitment, business management was explored.

2.2.2.1 HSE Commitment

Managers need to be responsible for HSE, while they have to be free in their decision making. In fact, they should be aware of their HSE situation and the risk level they manage.

According to the definition of HSE in the UK (1997), the policy of HSE is “[t]o set a clear direction for the organization and demonstrable commitment to continue improvements by considering the responsibilities to people and environment and satisfaction of stakeholders’ expectation (whether they are shareholders, employees, or their representatives, customers or society at large).” (UK, 1997)

Mortis (2009) interviewed workers in a construction environment in Belize to evaluate HSE commitment in managers. He reported factors that affected how unsafe work was, including poor HSE procedures and regulation of work environment, arbitrary obligation for wearing PPE\(^{12}\), no promotion or positive intention for managers for safe working, weak penalties from managers when faced with unsafe behavior, personal poor safety culture, abuse of tools and materials, cost saving by managers by cutting safety, and poor safety practice in the work environment.

He stated the following:

\[\text{-------------------------}\]

\(^{12}\) Personal Protective Equipment
All of these behaviors are because of poor HSE commitment of site management. Put safety out from first priority and lack of effective safety systems and heavy work pressure on workers are the evidences for poor commitment.

He continued that government and non-government agencies are unable to ensure that proper safety practices are adhered to in executive practice. He also explained a few important factors that have a significant impact on increasing the injury level in working environments.

The factors that increase the risk of management in the work environment are the fast nature of the work, involving numerous trades at the same time; changing labors and workers; the dynamic work environment; and work procedures (Mortis, 2009).

While much research highlighted the poor HSE performance of managers on HSE management, Steven (2004) requested greater flexibility for managers on safety decision making, meaning that enforcement rules and regulations could not guarantee business safety, and interrupted managers’ decision making.

2.2.2.2 Management Layers

The research on organizational safety layers in 2007 highlighted that the safety responsibilities and participation by companies would be increased if the safety attitude of all parties were improved (Ayyalasomayajula, 2007). This statement supports the idea that having a proper communication performance network would raise manager commitment. Flin, Yule, and Steven (2004) emphasized that supervisors have to permit a degree of independency for safety initiatives and open communication on safety. Moreover, they stated that procedural compliance should be guaranteed by the middle manager. Senior managers, site managers, and supervisors all have distinct effects on the safety climate of companies. Different research pointed to managerial responsibility and freedom, but few mentioned how a manager would realize the progress. Besides,
while researcher stated on the important role of managers in improving organizational safety, they did not develop the performance communication network.

2.2.2.3 **Subcontracting**

Subcontracting is one of the important elements in the business HSE management that blur HSE responsibilities between parties and lead to poor HSE performances (Laukkanen, 2007). Different researchers highlighted that smaller firms display a higher rate of workplace injury (Loewenson, 2001; Mortis, 2009). They requested more obligations in HSE requirements within any partnership, subcontracting, and regulatory inspection. Besides, they stated that integrated parties must be responsible for answering by employing proper HSE performance measurement. In fact, subcontracting has a great role in sharing the decision power and responsibilities of different parties. Past performance of the contractor is introduced as one of the best ways to improve the performance of contractors before inviting them to tender (Harris, 2006). However, the document was unreliable in most cases. In the following section, different approaches in subcontracting were discussed. However, all of them are prone to HSE negligence.

Laukkanen (2007) stated by outsourcing the contract, the main company (client) will turn the managerial control of the function to another company. The contractor has his standards and missions that are driven to profit from the services. Since many contracts have a fixed price for specific jobs, clients try to transfer all HSE responsibilities of a related job to their contractor at the least price. In fact, contractors always offer the basic cost of operation without attention to the risk transferred by their client within the tender. To minimize the risk of a project, clients should properly consider HSE expenses in line with its specification, before making a bid. For the contract without HSE coverage, clients must accept the increase at the cost of contract to rectify HSE costs that were not considered. This type of agreement without considering the HSE cost decline the claim of the contractor. Otherwise it would be a lose-lose contract in
terms of HSE for both sides and make them reluctant to take practical action for safety owing to saving their financial balances and facing penalties.

Sometimes the contract is made based on “payment by result,” which means payment is based on the amount of work, not on the amount of time needed. This strategy motivates contractors to minimize time and maximize profit, which always increases the risk of operation (Rowlinson, 2005). Compulsory HSE requirements might penetrate the organizational culture of the contractor if its requirements were requested directly by client managers. Rawlinson cited that some small contractors had a great HSE performance because their senior managers were interested in championing OSH, having positive partnering between the main client and contractor.

The other type of strategy in making contracts is engaging the contractors’ finance or products partially or completely as a project partner, “partnership contract.” Clients have free reign to conduct HSE requirements if the project finance is with them. By sharing the finance of the project with contractors or third parties, discerning the HSE responsibilities of participated parties would be difficult and challengeable (Kumaraswamy, 2000).

Delivery of HSE responsibilities in contract to the parties without HSE competency is kind of jobbery. In fact, many accidents and injuries are reported in projects and activities as a result of ill subcontracting owing to jobbery by the client. In the 21th century, discussions regarding the basic human rights of workers seem a silly subject, but again they receive subdual behaviors in terms of HSE. Foreign workers inside the country or people in developing countries in comparison with developed countries or people at contract in comparison with the main personnel of the clients behave like the second nation and are not similarly respected. In fact, the society is divided into different nations by different human rights or HSE conditions. Figure 2.1 (OGP, 2012) and Figure 2.2 (Holliott, 2010) highlighted a big gap between the HSE situation of
workers at the main company and its contractors based on the published statistics by two sample companies. These figures are adopted from the annual performance report of two large companies that care for their workers and contractors by considering HSE requirements in their bids. A double rate of injuries in contractors rather than the main company clearly demonstrated in these figures; however, they have tried to reduce these differences.

Figure 2.1: OGP 2010, Employees vs. Contractors, FAR performance

Figure 2.2: French Company (2010), Employees vs. Contractors, LTIF
2.2.3 HSE Slavery

Companies sometimes relocate their business or contractors to different countries to eliminate their dangerous activities from their direct spheres. In fact, this attribution is a modern approach of subcontracting to preserve business from direct complaining. There are different reports that highlighted some companies admitted endangering their partners or customers. This behavior is called slavery in today’s world, which is explained in more detail by the author.

2.2.3.1 Slavery HSE Behavior between Countries

There is no doubt that slavery is under progress, but the phrase changes in modern days. Globalization in different research is described as unequal exchanges in terms of wealth and anti-wealth (Arthur Shriberg, 2011; Aughenbaugh, 2009). In fact, resources from resource-rich countries will be passed to industrialized countries and again the adverse environmental and socio-economic consequences back to peripheral countries (Frey, 2013; Jorgenson, 2012). Many developed countries are permitted to export their hazardous products, environmental pollutions, and dangerous work conditions to poor countries to save the first nation countries and nations (Margai, 2011), but who cares about the appalling HSE situation at the receiver countries. Frey stated that

“...the transfer of core hazards to the periphery has adverse environmental and socio-economic consequences for many of these countries.” He stated that Health, Safety, and Environment risk have the globalization effect and not limited to the destination countries (Frey, 2013).

The shipbreaking industry is one of the spots for this unequal HSE behavior. According to Rousmaniere (2007), the cost of shipbreaking in developed countries was 50 times higher than in developing countries, so this industry was transferred from the US, UK, and Japan after the Second World War to Spain and Turkey in 1960 and Korea and Taiwan in 1970 and to South and South East Asia in the mid-1980s (Demaria, 2010). They sent their polluted industries and dangerous activities to the countries with
poor Health, Safety and Environment authority (Bhattacharjee, 2009; Frey, 2013). India and Bangladesh were two important regions for shipbreaking worldwide from 2000 to 2010, during which many workers lived and worked in appalling HSE conditions. Gujarat shipbreaking yard in India and Chittagong yard in Bangladesh are two well-known zones of danger. Many of their workers are poor people from the rural areas, employed on a daily basis to handle dangerous tasks. Most of them are illiterate (Demaria, 2010). Rather than severe social problems that exist at Gujarat or Chittagong yard, worse environmental degradation is the other severe outcome of these activities for people who leave in around. Many environmental problems arise from discharge of different hazardous materials such as fuel, PAHs, dioxin, radioactive, heavy metals, toxic paints, and chemicals, halons, and asbestos. According to a research, 5% of the total mass of one ocean-going vessel is its non-recycled waste (Breen, 2011). There is no reliable data of full occupational and environmental exposure at these yards because it is not possible to make an estimation of the actual number of deaths or cases of disease and injury (Frey, 2013). According to the statement of a doctor from Cross Red Hospital in Alang, “working one day in in the shipbreaking yards is equal to smoking 10 to 15 packs of cigarettes” (Frey, 2013). The French government in 2006 sent its warship, Clemenceau, to an Indian shipyard for recycling. The French government selected this shipbreaking yard in India to save five to eight million Euros just for avoiding European toxic waste regulations (Prakash, 2006), which is evidence of modern slavery in the 21st century.

2.2.3.2 Slavery Behavior with People Inside the Country

Many workers migrate to other countries with the hope of finding a better job or a better financial situation for their family. The UAE is one of these countries with many large infrastructure projects under construction with foreign workers. Millions of Indian, Bangladeshi, Philippian, Nepalese, Pakistani, and Sri Lankan laborers are working in
this country. They work for contractors of multinational companies that have different HSE policies; however, many of these workers live in inhumane conditions far from their home. In 2006, 109 Indian workers committed suicide, according to the Indian government (Aljazeera, 2007) and there are no real statistics of fatalities in the work area.

Sometimes, regional workers who work for foreign companies in their country work under appalling conditions. The garment industry is one example, involving commonly-worn brands in the US and Europe. Since 2006 to 2009, Bangladesh Fire Department declared that 414 garment workers were killed within more than 213 cases of fires (Sluiter, 2009) and in 2010, another 79 workers lost their lives within 21 separated accidents in this company (Muhammed, 2011). In May 2013, the garment building collapsed in Bangladesh, lead to 1127 deaths of low-paid women workers in sweatshop of garment factory. The majority of the workers received less than US$40 per month for 14 to 16 working hours, approximately ten cents per hour. This rate is incomparable with hourly wages of US$14 per hour of a worker in the US (Press, 2013). The garment export industry in 2011 was worth more than US$17 billion from Bangladesh to the US while over three and a half million workers lived in appalling HSE conditions.

The ILO convention 155 in terms of health and safety and UN guidelines for Business and Human Right signed by many countries in 2011, provided a framework of responsibilities for both government and business. However, workers, especially foreign workers, possess little bargaining power to get the job (Gray, 2008), let alone a safe job.

Garmont (2011) signed a memorandum for the implementation of a Fire and Building Safety code. Different responsibilities were assigned to groups from government to factory owners to enhance the HSE conditions. Many elements were considered in their plan, such as establishment of a task force, oversight committee and chief inspector nomination, factory participation plan, inspection and follow up on
corrective/preventive actions, providing a complaint mechanism for workforces, reviewing the building standards, training program, Health and Safety committee, supplier engagement, financial support, and audit programs. This plan was initiated in 2012, but six months thereafter, a collision lead to more than 1127 deaths.

This example again reveals the root problems mentioned in the case of BP’s accident in the first chapter. The other important point in garment factory incidents is the priority of time in HSE management system and performance management. Many new suggested HSE practices by the fire and safety memorandum were launched and put into practice six months before the building collision. If a manager has the proper tools to manage their HSE performances on a monthly basis, instead of reporting what they did, they could realize that they have to work harder and might prioritize some other subjects. Alternatively, in the case of the mentioned accident, many of them could be preventable if managers were informed sooner before the accident.

Three weeks after the garment tragedy, over 30 of the top global retailers signed up for safety groundbreaking deal with brokers by the global trade union (Congress, 2013); however, the way to measure HSE performance is also under question. If they could not find the proper HSE indicators to make them clear regarding the HSE situation at the right time, then they will be informed after the occurrence of some other accidents.

The author also studied the legal support of foreign workers in Malaysia. The Malaysian social security organization provides social security protection by social insurance exclusively for Malaysian workers and permanent residents under the “Employees Social Security Act 1969.” This act does not cover foreign workers and domestic servants employed to work in private residences (cooking, gardening, drivers, etc.) The Workmen’s Compensation Act 1952 will compensate the injured person or his dependents in case of death; however, this act does not apply to the foreign workers with wages more than RM 500 per month. (MALAYSIA, 2012). Therefore, if one is a
foreign worker and receives a monthly salary below 500 MR, he/she is living below the poverty line, which means working in appealing HSE situations. On the other hand, if one receives more than the MR 500, there is no support. In addition, Malaysian Occupational Safety and Health applies only to Malaysian workers and not foreign workers. This means that none of the injuries and fatalities of foreign workers should be recorded and considered in statistics (MALAYSIA, 2012). And so, when there is no care about this statistic, there is no support or policy making for this group.

Ultimately, the prosecution is only considered for employers who failed to comply, supported by employee social security regulation 1969. It does not hold for alien workers. Therefore, this regulation is trying to limit the fatality in statistics and it could not promote the companies to improve its safety efficiency, especially when they employed foreign workers.

According to the mentioned regulations, the following three different policies get foreign workers in danger of death in Malaysia and unequal HSE conditions:

1- Less payment to the foreign labor, who works in severe/unhealthy work environments
2- Less compensation in case of injuries
3- Less prosecution against who failed to consider the labor’s right

The garment factory is also established in Malaysia and they get the CSR certificate, emphasizing attention towards stakeholders, including workers, communities, regulatory bodies, and stockholders. The research conducted in 2010 at the Malaysian garment factory did not confirm the assumption that garment CSR provides sufficient protection for both Malaysian and foreign workers (Crinis, 2010). Moreover, it revealed the important point that, in contrast to Malaysian workers that had

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no claim of violation, there have been claims of foreign workers for violations. This evidence highlights the above statement regarding the negative policy against foreign workers in Malaysia.

One might ignore responsibilities toward others in their work environment but its negative impact would occur in other place in other time (e.g., the crime committed by people who lost their parents in the work accident). The author believes that HSE at the society level will be established when society respects the HSE of other societies.

2.2.4 HSE Culture

2.2.4.1 Definition

Previous sections highlighted the need to redefine and reorganize HSE responsibility distribution within companies. HSE regulator and management systems try to direct organization to care on HSE requirements in the work environment and to manage its impact in nearby communities; however they cannot penetrate the real life of the organization unless the people decide to make a change themselves. Improving HSE in an organization has its root in changing humanity and the attributions of people in a win-win contribution.

An organization is a group of people who work together toward the same goal but with different reasons. Any organization has many nested organizations, which interact. In this case, measuring HSE performance of an organization was done by recording the performance of all subsidiaries.

HSE culture is understood as the final outcome of HSE interaction between responsibilities over the long term. Many different models have been introduced to measure the HSE organizational culture, the assessment of which is outside this research scope.
According to the definition by Piers (2009) and Misumi (1998), HSE culture is the outcome of a desire for goodness by people, organizations, and the public, achieved by the participation of all people to be responsible for all.

Two phrases of safety climate and safety culture sometimes combine. Their differences can be adopted based on the definition provided by Thaden (2007):

\[
\text{Safety culture is commonly viewed as an enduring characteristic of an organization that is reflected in its consistent posture with critical safety issues. And safety climate is viewed as a temporary state of an organization that is subject to change depending on the features of the specific operational or economic circumstances.}
\]

This means that safety culture is the resilience of an organization in dealing with safety challenges nested by the safety commitment of the individuals. However, safety climate demonstrates the outcome of safety culture in exposure of business pressure at that particular time at that place. So, changes to the safety climate are faster and depend more on managerial decisions based on resources at the scene. On the contrary, the fluctuation of the safety culture is smoother in the long term, as it influences personal responsibility and beliefs.

2.2.4.2 Theory and Philosophy

Business HSE culture by participation of all parties is rooted in social theory and philosophy. This section provides an insight into two related theories and one philosophy that provide evidences for the responsible attitude of people. In the view of social studies, two human theories and one philosophy address human responsibilities toward themselves and others.

(a) Douglas McGregor Theory

In 1960, Douglas McGregor formulated Theory X and Y that suggested two aspects of human behavior at work, classifying the perception of human behavior as one of two types, X and Y (McGregor, 1960).
Based on theory X, people of type X are negative. On average, these people do not like work and try to escape its responsibilities whenever possible. This group generally dislikes responsibilities and resists change. So, humans must be persuaded, forced, or warned with punishment, since he does not want to work. In this group, many employees rank job security as highest, and have little aspiration/ambition. This attribution in terms of HSE is seen in many managers who try not to be responsible for their HSE decision. It means measurement systems need extensively to monitor the HSE performance of people in group X.

In contrast, group Y people are perceived as relaxed in their tasks. Both physical and mental effort is exercised and responsibilities are recognized and admitted. Their skills and competencies are fulfilled so they are innovative and creative in solving related problems. They can learn to take responsibility and there is no need for external control and enforcement, as they are self-directing or self-controlling. In fact, group X and group Y represent two opposite HSE cultures, in which group X never cares for stakeholders and group Y always does.

How can we change group X to move toward group Y? Douglas highlighted that this could be done with close performance observations. Maslow suggested that this change would occur through passing maturity stages; however, it should be achieved within the time frame. In fact, Douglas built a frame to enforce people to move from group X to group Y, while Maslow’s theory shows the people desire to move.

(b) Maslow’s Hierarchy of Needs Theory

In 1943, a psychologist, Abraham Harold Maslow, suggested one of the most popular theories of human motivation. His theory was based on a hierarchy of human needs. He believed that human behavior is dependent on his needs until those needs are acquired. In 1954, five types or sets of human needs were arranged in his (Maslow’s) proposed hierarchy based on importance and priority (Maslow, 1954). He concluded that, when
one set of needs is satisfied, it seizes on the next motivating factor. Thereafter, the next set of needs in the hierarchy order takes its place.

Self-actualization, ranked as stage five in the five-stage pyramid. By fulfilling one's full spiritual and intellectual potentials, he becomes creative and desires. This stage means a man being converted into what one is capable of being or being what he was made in complete God’s image (Elton True blood). Because a man’s potential consists in a wide range of talents, his complete maturity is dependent on fulfillment in many underlying fields. The progress at this stage needs a long time and efforts to be achieved.

![Maslow's Hierarchy of Needs](image)

**Figure 2.3: Maslow new adaption hierarchy of seven stages**

As shown in Figure 2.3, Maslow revised his hierarchy from five to seven by adding two levels in the 1970 revision of his book, *Motivation and Personality* (Maslow, 1971). These two levels were 1-Needs to know and understand as cognitive needs and 2-Aesthetic needs with emphasis on a conception of beauty or deep fathom of art (sensory stimulation). Moreover, they expressed that, at the end of Maslow’s life and
after his death, others took up his work and found the eighth level: transcendence, which means helping others to achieve self-actualization, and includes global concerns.

No matter how he classified the lower level, Maslow believed that self-actualization is a process of continuous growth. Maslow said in his book

\[ \text{At this moment (self-actualizing moment) of experiencing, the person is wholly and fully human. ...As counselors, we can help clients to experience them more often. We can encourage them to become totally absorbed in something and to forget their poses and their defenses.} \]

He emphasized that the growth choice instead of the fear choice move people a dozen times a day toward self-actualization. In fact, any of our daily single choices is a case in an ongoing process towards self-actualization. He said:

\[ \text{Each of many single choices about whether to lie or to be honest, whether to steal at a particular point...are a choices as a growth choice.} \]

Although Maslow did not mention any criteria on how to discern good and bad and why people choose good or bad, he believed that goodness is the fundamental of human and evil merely a reaction to circumstance. (Maslow, 1968)

Stage five up to the highest stage are called Being-needs or “B-needs” and refer to the cognitive needs, esthetic, self-actualization, and transcendence needs. Maslow concluded

\[ \text{I have found approximately as many transcenders among businessmen, industrialists, managers, educators, political people as I have among the professionally “religious,” the poets, intellectuals, musicians, and others who are supposed to be transcenders and are officially labeled so.... Any minister will talk transcendence even if he hasn’t got the slightest inkling of what it feels like.} \]

Although Maslow’s hierarchy of needs theory has been criticized, it still shows the simple fact that human beings are motivated by unsatisfied needs. He also stated in his book that:
“Remember, every action or behavior is not motivated by needs or desires, and everyone is not motivated by same needs.”

While limited theories discuss human responsibilities, the author found an Islamic philosophy by Molla Sadra Shirazi from 1600 years ago that stated how humans could raise in a chain of responsibilities and needs.

(c) Molla Sadra’s Philosophy

Molla Sadra was one of the greatest Islamic philosophers and lived from 1571 to 1640 in Iran. He is famous because of his Islamic philosophy, which provides a clear map for humans to climb toward his destiny layer by layer, changing from a non-responsible to completely responsible person (PIRI, 2011).

According to the Molla Sadra’s philosophy, people pass four stages to achieve his own excellency and highest responsibility (e.g., becomes Imam or Majesty). He described the details of these four transitions in four volumes, but in summary the stages are as follows (Rizvi, 2002):

1. Movement from human primary needs to the cognitive needs; (awareness)
2. Movement through esthetic needs; (assessment of the facts)
3. Movement from aesthetic needs to the self-actualization; (self-management)
4. Movement within transcendence level between people; (leadership)

At the first stage, “deficiency needs” were introduced as one transition stage that includes both biological and social needs of humans. According to Molla Sadra, there was no priority between biological needs or esteem needs for people at the first stage. One may prefer to be hungry instead of bearing with a lack of admiration and vice versa. He believed what made people able to accept this internal pressure, to some extent, was their responsibilities and their determination.

“Needs” and “responsibilities” will act simultaneously to move humans in a sustainable manner. A man could not be responsible without attending to his basic
needs; on the other hand, he could not perform based on his needs while ignoring his responsibilities. Responsibility is a separate dimension from human need. No matter what combination of biological or esteem needs a man has in his life, one has to follow his own responsibility instead of being selfishness. Interaction between human needs and responsibility shapes commitment. Observation of commitment is done in the second stage of Molla Sadra.

Within the second stage, desire of awareness and curiosity conduct people to fathom the beauty of spirituality and their commitment that penetrates to the sensory life. More assessments bring more awareness and responsibilities, which motivate him to make more efforts. Self-controlling at the third level makes him susceptible to realize the actual power of a human being and be responsible for self-controlling. If a man passed all the previous stage on goodness, then he would be a responsible human. In the fourth stage, this man becomes a leader of others, helping them to be more responsible and empower themselves to be more curious about the outcomes of their decisions and to be self-driven in practices.

There are many different subjects that people need to be responsible for and this cycle may repeat for different responsibilities. With aging, people become leaders in some tasks but not in all. At each stage, people may stop to climb the ladder; however, they cannot regress to the lower level as they learn the truth. So, efforts for back to the lower level mean he denies what he acknowledged. People just can deny what they have realized to escape of their responsibilities. According to Molla Sadra, at the Day of Judgment, people have to answer for all their responsibilities they were trying to deny in this life.

(d) Summary

Business, companies, or workers are part of the bigger community in which they live or work. They need to be responsible toward others affected by their practices.
Considering the rights of stakeholders was considered essential for a win-win collaboration. HSE culture would be the outcome of these responsibilities that was divided by Douglas into the two groups of X and group Y. Continuous observation would help people in group X move to group Y. This transaction was divided by Molla Sadra’s philosophy into four stages for each concept of responsibilities. It started from awareness of responsibilities while the basic needs should be fulfilled, then extended by assessment of those responsibilities. Next, one should become a self-manager on this responsibility to rectify the situation or outcomes of their practices. Finally, by perseverance one becomes a leader with concern to help others to be responsible for others as well.

At each stage, people may refuse to climb the ladder; however, they could not regress to lower level as they acknowledge that. They just try to deny their responsibilities at that level. By using the effective observation and setting enough motivation, managers would conduct themselves and subsidiaries to be responsible for the HSE impact of their activities. In fact, Molla Sadra philosophy supports the statement of BP’s investigation that asked for “making differences between good and bad performances.”

2.2.5 HSE Management Models

Previous studies in early sections highlighted a wide range of shortages in HSE responsibilities to stakeholders by managers and to the societies affected by these. The X and Y theory and Molla Sadra philosophy also affirm that people should be responsible for the outcome of their practices. However, an effective observation system is essential to shift one from a non-responsible to a responsible group. Different HSE management systems might be employed in companies to guarantee continuous improvements.
Different Safety, Health, and Environmental Management Systems were developed, such as ISO 14001, OSHMS by ILO, OHSAS 18001, EEC 1836/93 European Union, BS 8800, Australian Safety Map, Voluntary Protection Program (VPP), and ANSI Z10. According to the discussion in section 2.1.1, companies could not support different management systems at the top level unless they completely merged.

2.2.5.1 **Behavior Base Safety (BBS)**

Attention to unsafe acts and unsafe conditions caused the terms of the human Behavior Safety System widely used since 1990 in the company’s management system (Krause, 1997). Business culture could not be built by procedures, audit observations, and inspection; however, they could affect HSE climate in the short term. BBS assesses worker behavior, determines their failures and directly affects the behavior of people. Molla Sadra mentioned the fact that moving from group X to group Y lasted in four stages to change an irresponsible man to a truly responsible man. People might deny their responsibilities after they realized them; however, proper observation would enforce them to be responsible over the long term.

Behavior Base Safety could be applied consistently with different management systems at executive levels. In this model, every worker is responsible for himself and for others that might be affected by him (Amoako, 2013). This approach increases worker involvement while motivating them to participate more. Unsafe acts are understood as the root cause of many of incidents, thus, people are invited to observe their fellow workers and let them complain about others to protect themselves (Grindle, Dickinson, & Boettcher, 2000). According to Turnbeaugh (2010), successful companies in implementation of BBS used workers incentive system to distribute the proper positive attitude at the first stage.

Performance measurement in BBS built on the frequency of critical safety behaviors, the number of feedback or rate of inspection for data collection. Brown and Barab
(2007) claimed a dramatic reduction in the rate of injuries in a giant construction company, as a result of using BBS. Their injury prevention strategy was based on three factors: 1) cash incentive for reporting injuries and illness, 2) support who report, 3) employing friendly clinics and compensation insurance company. By using these factors, the BBS has achieved a reduction of 55% to 72% of injuries compared with their competitor in that region. However, they had being sentenced by safety authorities because of failing to record 13 worker injuries in 2006 (Brown & Barab, 2007). This shortcut demonstrated why BBS alone could not be effective for cultural improvement and highlighted the importance of having a separate observation system. The recent research by Amoake (2013) contradicts Brown’s statement. According to Amoake, while this model was interested by many companies, he highly criticized that BBS was not an effective tool to prevent the injury as a safety management system.

The author believes that these two standpoints are further evidence supporting the importance of Douglas theory and the philosophy of Molla Sadra. The system could not expect that people change their behavior without an intensive monitoring system. Besides, BBS is most suitable at the operational or executive scale and not at upper organizational levels. Geller (2001) stated that interpersonal observation and feedback were crucial parts of BBS; however, feedback without commitment to eliminate hazards and to rectify situations would not be effective.

2.2.5.2 Voluntary Protection Program (VPP)

The voluntary protection program in the US was another safety system that can add locally to the main business management. VPP was designed based on four aspects, including: 1) Manager leadership, 2) Employee participation, 3) Workplace analysis, 4) Hazard management and OSH training (Lasowski, 2010). It is consistent with Molla Sadra’s philosophy, which stated four stages of human responsibility growth. During the VPP program, companies in the US voluntarily participated in the OSH program and
received the lower rate of governmental inspection if their safety management system performed at acceptable levels.

The VPP program is designed based on collaboration of OSHA, employees, and employer, which all play important roles to improve safety conditions in the workplace. VPP foundation is the responsibility of managers for their workers’ safety (Hansen, 2006). In VPP, OSHA asked the company to declare their plans for a wide HSE program. However, asking about self-assessment by company could not create enough motivated managers to put the safety on their first business priority?

In VPP program, the government collects the Days Away or Restricted or Transferred duties (DART) rate from the companies for three years and compares it to recent published rate by the Bureau of Labor Statistics (BLS). Then, the companies with low accident statistics will receive rewards, such as lower monitoring rates by OSHA inspectors.

2.2.5.3 ANSI“Z10

The American Industrial Hygiene Association introduced the other Occupational Health and Safety management system to improve the health and safety conditions of companies and reduce injuries and illnesses. The main components of Z10 are: 1- Management leadership and employee participation, 2- Planning of health and safety plan, 3- Implementation, 4- Evaluation and 5, Management review (Palassis et al., 2006). Similar to other HSE management system, in Z10 companies also set their goals almost on zero accident, zero incident, zero lost, zero waste, zero discharge, zero defects, etc. (Wee & Quazi, 2005; Zwetsloot et al., 2013).

The Z10 places an emphasis on the training and awareness program, worker participation, document control and procedure, system audit, conducting an accident

14 American National Standard Institute
investigation, risk assessment and implementation of corrective actions. This management system properly underlines worker participation as one of its basic foundations. However, the way for performance measurement is open for companies.

2.2.5.4 Summary

Management systems just present a draft for continuous improvement through different elements. BBS and VPP could support a small portion of business management; however, the Z10 tries to introduce complete management systems, which work as main business management systems.

All systems request more responsibilities of managers and workers on HSE. However, referring to discussion on business management, companies try to set up one general-purpose management system that supports different strategies. Therefore, while ANSI Z10 is one of the most outstanding developed safety systems, it could not be set up directly in the organization as the second system. The HSE department needs to compile the Z10 requirement in line with the main business management system.

2.2.6 HSE Management System Theme

Regardless of extensive efforts to develop and audit the management systems after decades, the occurrence of incidents remains above the desire level. Amok (2013) stated that the US workplace is currently susceptible to incidents, while the negative social and financial impact of accidents cost the US. This applies to situations in which different management systems, safety regulations, and company inspections are in progress.

The author found two different business strategy in organizations.

2.2.6.1 Integrated Management System vs. Agile HSE Management System

Integrated Management System (IMS) and HSE management systems are two related systems built with two different approaches. Many of the mentioned safety and environmental management systems could be addressed using these two approaches. Both follow the same goal but using two different tactics.
An IMS certificate is awarded to a company that set up three management systems, including ISO 9001, ISO 14001 and OHSAS 18001. Then, a certification body would accredit them periodically on their separate policy (three policies). In IMS, a company should grant the resources and budgets needed to run these three systems. These situations are not achievable in many operational activities, especially in companies in developing countries or SMEs. Limiting resources prohibit companies in their spending on all IMS requirements in detail. A company should plan its operation in the shortest time and in the most cost effective manner. So, they could not overcome most IMS requirements. Therefore, companies preferred to transfer all responsibilities requested by IMS to few people and contractors instead of involving their whole organizations.

IMS is just a symbol of physical integration of three systems (OHSAS, ISO14001 and ISO9001) together and not merging them in one spiritual approach. Hendren et al. (2013) stated that OSH management standards provide a written draft for safety management in organizations. OSH management sets up a network to achieve safety and health requirements in the business, with rigid documentation and transcription. This attitude is beyond approaches assumed for business flexibilities (Preiss, Goldman, & Nagel, 1996). The other recent study stated that IMS with three separated managements were difficult for managers to uphold (Zeng, Tam, & Le, 2010). Zeng stated that IMS enforced managers to have written procedures for their tasks, to make them traceable and auditable. These requirements are tough on managers, with many documents, forms, written procedures, and other controls. They band manager flexibility in decision making and fast practices. In fact, the IMS exerts extra pressure on organizations and is always handled by few staff members.

During the interview at this research, one of the line managers highlighted an important statement about IMS. He said, “just fill up the forms and documents to show the system is in progress; don’t say HSE problems if you don’t want to put yourself on
troubles, everything must move perfect on safety!” It should be noted that IMS would not benefit companies that do not encounter financial problems; however, its efficiency is in doubt.

In contrast with IMS, HSE management with agility concept is the last approach introduced towards business flexibility. The HSE management system is primarily developed by some international world-class companies early this century. They needed a tailor-made arrangement that matched their operational more than their external authorities’ requests. It is important to ensure that, in practice, Health, Safety & Environmental requirements should be part of each management system; however, it should be strong, reliable and quick to support HSE changes in line with the operations.

Different to IMS, accreditation of HSE management guaranteed by the company’s brand and not by the certification body. HSE commitment is the basic responsibility of all workers and managers instead of a few management representative teams. Operational managers build their HSE performances in collaboration with their teams and subsidiaries. The HSE department is not the sole responsibility of the organization. The company does not need a separate HSE policy, as it should be part of the main business strategy (for example, sustainability).

The IMS approach exhausts the organization with extra documentation and a blaming culture as observation done on documents. This attitude highlights documentation rather than accountability. Scarcity of time and budget leads to some shortcuts distributed in the system. By collapsing the first pillar, the whole system will be ruined as it is maintained by force of inspections. The HSE agility approach, trusting registered experts, may motivate them to be more accountable; however, they might take higher risks than the acceptable level.
To shift the organization from heavy and rigid management toward the light and process oriented decision-making, the agile concept is suitable. In fact, managers are able to plan quickly, set up quickly, and be more flexible in integrating their re-organization and reinstallation (Rebelo, Santos, & Silva, 2013). More discussion regarding the differences in HSE approach is highlighted in the section of HSE tactics. However, no matter what management approach is being chosen by the company, it cannot be effective until its performance is measured at the level of all decision makers and present their HSE responsibility.

2.2.6.2 HSE Tactic

Managers have to set their working strategy (tactics) in line with the business strategy. Working objectives, working tactics, proper organization of people and distribution of responsibilities, and eligible depth of decision would be consistent with this business strategy. Assuming a business strategy was set in line with sustainability, it is necessary for all running tactics of all departments to be justified by the sustainability approach, including commercial, Human Resources, manufacturing, IT, etc. Otherwise, the sustainability strategy represents solely an advertisement window for companies.

IMS and HSE agile approaches are the foundation for fulfilling Occupational Safety and Health or Environmental (OSH&E) requirements. This approach in practice would cause: 1- Stop job until all procedures and forms and requirements are clearly defined and passed, then execution commence by having the approval in hand (e.g., permit from HSE departments). 2- Let the competent team who is registered in HSE, commence their task and make HSE decision by itself within execution.

2.2.6.3 HSE Objective

OSH&E management systems require top managers to show their commitment to written safety and health and safety objectives. The strategy of zero incident/zero
accident has been reported since 1970 (Cohn, 1970) but again this strategy is repeated after 40 years.

On the point of organizing, objectives should cascade into working levels. In fact, each business manager has to define their HSE working objectives so as clearly to support their business objectives. Cable, Davis, and Hoc (2005) also highlighted that organizational goals and missions should be cascaded to management levels. Mohapatra and Singh (2012) introduced four cores for business objective, including cost, process, safety, and environment. In contrast to Mohapatra, who allocated half of the objective cores to HSE requirements, the author believes that the objective should have four layers: 1) throughput, 2) costs, 3) HSE risk, and 4) time. In fact, these four layers should be set in each objective by managers.

Selection of zero objectives could not demonstrate HSE risk and reliable performance within business activities. HSE objectives should be able to monitor changes of risk within the time frame for working objectives. Separated HSE objectives might be set for the HSE department (e.g., expanding waste recycling or increase HSE inspection rates) but again, it should respect the mentioned four layers.

Attention to the changes at the HSE risk is an important layer to set objectives (e.g., pure operational objectives, IT objectives, etc.).

It emphasized that HSE objectives should not be considered as a separate objective, but rather as attached to the other business objectives. In fact, HSE is one of the four layers that should be respected within each objective.

2.3 HSE Report and Performance Measurement

A successful management system in practice depends on how manager responsibility is evaluated by systems in fulfillment of their objectives. This observation depends on the reporting systems and the indicators employed to measure the concepts. Researchers stated that improper HSE reporting was seen in communication both internal and
external to the organization. Consistent with Milne (2001), who underlined the poor communication between managers, Rawlinson (2005) highlighted poor communication between companies and their subsidiaries and contractors in safety management systems. Besides, non-effective communication causes managers not to probe the depth of challenges they faced. On the other hand, communications would affect managerial commitment by presenting their past performances and differences in their objectives. Fisher (2010) stated that lack of communication may cause organizations to become weak on HSE commitment and to have poor HSE performances. Unfortunately, managerial communication in terms of safety and environmental performances are poor at the company level (Choudhry & Fang, 2008). Such communication has always been used to claim against companies or workers. The blaming culture in HSE communication would increase the tendency of denial in managers instead of their being more responsible, decreasing HSE communication in a company or among organizations.

This section has closely examined different analyzing and measurement systems advised by a variety of organizations. Some of them supported direct HSE reporting and some were adapted from other fields. The author classified them into three categories: 1) Partial HSE performance measurement, 2) Inclusive HSE performance measurement, and 3) Risk base performance measurement. Before discussing HSE, it is necessary to define some phrases.

2.3.1 Performance Measurement Definition

According to the HRSA (2011), performance management is a process for setting objectives and continuously checking progress toward a goal. A similar definition was defined before him, by Elg and Kollberg (2009), who defined performance management as the process of collecting, computing, and presenting quantified measures for managerial follow up and organizational improvement.
Performance measurement was defined by HRSA as a process to allow a company or an organization employed to monitor important aspects of its objectives. In fact, performance measurement is a frame to request data and information on a special concept. HRSA defined performance measures as a designed form to collect data on specific subjects or measurable elements of the concept.

Franceschini, Galetto, and DomenicoMaisano (2007) defined the phrases metrics and indicators as parallel to each other. According to him, choosing the right indicator is a critical aspect in translating the organization’s strategy into reality while strategy without indicators is useless. A misalignment of indicators with business objectives or the selection of the wrong indicator that inadequately addresses the concept was introduced as a main source of business ineffectiveness and communication interruptions (Franceschini et al., 2007). According to their research, indicator time dimensions (short term-long term), indicator usage, and their nature will affect managers’ decisions and actions.

Franceschini (2007) stated three important functions of a proper indicator: 1) controlling, which helps managers realize the situation of concept and be aware of its changes, acting like a window; 2) communications in management languages, which should have the same meaning to internal and external parties, preventing frustration and confusion in stakeholders; and 3) actionable, an indicator that should be affected by the managers’ decisions as they should highlight their responsibilities (e.g., performance improvement).

According to the UNDP (2002), indicators are signposts of change along the path toward development. The author believes that indicators and measures are the same, but the concept of their usage nominated them differently. Both (indicators and measures) are the observation at the current time and may be a reference point for a decision. The difference is that an indicator has a norm by itself that shows differentiation from that
while a measure does not have such an indicating norm with itself. On the other hand, both can be traced in the time line to understand its progress and its trend. Indicators might be substituted with measures; however, there are many limitations to defining criteria, in most cases. Measures could easily be defined and logged for different purposes, even if there are no criteria for that.

Liao and Hsiao (2013) defined *Key Performance Indicator* (KPI) as the most important objective measure of performance, while they did not highlight the difference between performance indicators and KPI. Neglecting this can be seen in another study by Ling and Peh (2005). Other researchers stated specification of KPI. Ahmad, Mansour, Dhafr, and Ahmed (2012) stated that KPI should include safety, environment, flexibility, innovation, performance, quality, and reliability; however, they did not suggest any KPI. Parmenter (2010) stated that KPI is a measure that is most critical for the current and future success of business in the special aspect of organizational performance.

2.3.2 **Partial HSE Performance Measurement**

Partial measurement refers to the measurement system not developed for safety measurement purposes; however, it may be employed. In fact, the partial management system provides a frame for measuring an open concept. Partial performance measurements are open measurement systems that allow managers to use different performance measures. Accuracy and reliability of systematic performance measurement are highly dependent on the validity and reliability of the involved indicators or measures. In fact, a partial measurement system is a frame with a mathematical process for the input data.

Different existence systematic frameworks were studied by researchers almost on throughputs (products or services), such as TQM and Six Sigma (Bonham, 2008). Turnbeaugh (2010) explored different measurement systems used by companies to
control their performances in the concept of customer satisfaction; however, these models might be used for managing other management concepts, such as HSE. Turnbeaugh underlined Total Quality Management, Six Sigma and Behavior Base System as three managerial tools that help companies to improve their operations by minimizing failure rate at both operational and administrative levels. Ciemleja and Lace (2008), in another study, proposed Six Sigma, TQM, and Balanced Score Card (BSC) as business measurement tools (BMT) suitable for the different measurement context. While TQM and Six Sigma are helpful on an operation scale, BSC benefits the strategic level. In the next sections, employing these measurement systems in the HSE concept will be discussed and evaluated.

2.3.2.1 Total Quality Management (TQM)

TQM is a measurement system developed for managing customer satisfaction. In 1952, in Japanese industry, TQM was defined as the continuous improvement of either products or services (the throughput layer of objectives). Some organizations extended this model to monitor safety management. The key points for TQM systems were defined by Edwards and Deming in 1982 as a management tool to improve their quality objectives (Deming & Edwards, 1982). In this section, the process of TQM will be explained while its usage for measuring the HSE layer was argued by the author.

1- TQM starts with the selection of objectives seeking continuous improvement in sight of competitive business. In fact, it focuses on one concept of objective for improvement. Deming stated two problems: Problem of today and the problem of tomorrow, so just concentrate on the current challenges (Deming & Edwards, 1982). On the contrary, HSE is looking for the whole performance outcome not only at the present but also at the future. This concept is different with TQM, which ask managers to directly concentrate on the first business priority and to limit themselves just in the circle of business objective.
2- Deming highlighted that the measurement of a concept should be preceded by the outcome of the same concept. HSE performance is also a separate layer from financial, throughput, and time, which should be preceded by a similar outcome.

3- According to Deming, no one can put in his best performance unless he feels secure; thus, no blame culture is the other essence of TQM. This attribution is also essential in HSE, is twofold. First, protecting people who report their HSE challenges, deficits, or incidents. On the contrary, irresponsible people should feel insecure if they put others in danger. Similarly, if the managerial decisions lead to fatalities or unsafe acts, they should be responsible as well.

4- Eliminate the zero target from the workers’ performance. Deming believed that achieving the zero goal is not the responsibility of workers, but is the burden of systems. Within the HSE system, having the zero goal is the responsibility of all.

5- Deming stated that the work production standards and operational norms and rates linked to incentive pay are inappropriate in the long term in TQM. This fact also applies to HSE performance measurement in the long term.

The usage of TQM tool in the safety management system was described by OSHA (2006), in which safety goals could be substituted by the business objectives. However, the business goal is safe operations and not sole safety. Wilcox (1994) showed that, in general, TQM was considered a second- or third-order strategy in business by itself. In the same manner, Yu and Hunt (2004) underlined that TQM could be helpful for companies to initiate a change in their safety management system; however, this would be difficult for a company to design and maintain. Podgorski (2000) introduced TQM as an operational frame by which to track progress of long term business while reaching its goals in the short term. The author believed TQM could be helpful for local improvement in technical services by the HSE department.
2.3.2.2 Six Sigma

Six Sigma for the first time was implemented in the Motorola company in 1986 by Bill Smith (Sony & Naik, 2012). Six Sigma is the measurement framework that helps managers by comparing the variations of the performances. It could be used to identify the waste of projects or operation or activities as a result of the material, resources, time, energy, and others if these were beyond the acceptable level. Six Sigma is classified under the partial measurement system as it provides a frame for using and processing different indicators. Six Sigma usage depends on what objective has been selected for measurement and how reliable the collected data is. In fact, by using Six Sigma, companies perform an investigation of the subsidiary elements that cause variations in their services.

Although Six Sigma was developed for customer satisfaction by minimizing the rate of deficits to a minimum level of probability (e.g., 3.4 failures per one million probable cases), this technique could be implemented for any other deficits probability rate, as highlighted in Table 2.1. Fundamentally, Six Sigma is considered the probability of unacceptable events out of total probable events. Normal distribution of probable cases was defined by Carl Fredrick Gauss in the 18th century. Further, the three sigma concept is defined as an acceptable level that a process may be required for its performance reliability. 1 sigma, 2 sigma, and 3 sigma indicate coverage of 31%, 69%, and 93.3% of acceptable case per total cases (variation around the average). From the negative view, 1 sigma, 2 sigma, and 3 sigma indicate a 69%, 31%, and 6.7% probability of deficits in the total probable cases, respectively. Further, by raising the sigma level from 4 to 6 sigma, the coverage would be 99.38%, 99.977%, and 99.99966% of positive coverage. From a negative perspective, this means a 0.62%, 0.023%, and 0.00034% chance of deficits (Table 2.1). Six Sigma emphasizes 3.4 deficits in one million cases. This rate is meaningful within the time or when extra cases
become available. If the mean of the measure is changed, this formula tolerates its variations being changed to plus/minus 0.5 sigma, as demonstrated in Figure 2.4.

<table>
<thead>
<tr>
<th>Sigma level</th>
<th>Positive coverage</th>
<th>% defective</th>
<th>Number of deficits per 1 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>31%</td>
<td>69%</td>
<td>691.462</td>
</tr>
<tr>
<td>2</td>
<td>69%</td>
<td>31%</td>
<td>308.538</td>
</tr>
<tr>
<td>3</td>
<td>93.30%</td>
<td>6.70%</td>
<td>66.807</td>
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<tr>
<td>4</td>
<td>99.38%</td>
<td>0.62%</td>
<td>6.210</td>
</tr>
<tr>
<td>5</td>
<td>99.98%</td>
<td>0.02%</td>
<td>233</td>
</tr>
<tr>
<td>6</td>
<td>100.00%</td>
<td>0.00%</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Figure 2.4: Distribution of different levels of sigma

Acceptable deficits rate in HSE must be managed by respecting other concepts. For example, the probability of failure in airplane maintenance under the level 6 sigma is acceptable (3.4 case of deficits in one million cases), while delivery time in the normal supply chain at the level 3 sigma may be more than sufficient. Six Sigma is a helpful technique for partial HSE improvement; for example, waste minimization, emergency response time, and failure rates. However, it is impossible to aggregate the overall performance measurement.
2.3.2.3 Audit System

The audit system is the foundation of many decisions based on the preparation of a list of non-conformance records. The manager would act for corrections, and the system would undergo another audit. Audits should have a proper organizational frame with clear weighted elements to help auditors spend enough time on that. An audit is carried out on the documents, manuals, procedures, and evidences. In the variety of Health, Safety, and Environmental Management Systems, such as OHSAS 18001, Z10, and ISO 14001, the audit is considered part of the system requirement. It should be noted that system implementation does not necessarily mean system performances. Auditors always audit the framework of the system, not its contents.

The aim of the audit in the systems is to identify whether the designated policy or objectives are achieved by the company and what sort of corrective actions need to be developed in the company for continuous improvement. The audit result will always be discussed in the management review meeting. There are many claims against the unreliable outcome of audits by researchers (Weiss & Wagner, 2000).

The positive side of the audit is that it is helpful for research studies to benchmark some variables. Besides, one can understand the overall concept of implementation mentioned in the procedures. However, it would be difficult to integrate it with the other business or subsidiary’s performance. Performance measurement by an audit may be different from questionnaires, while the same questionnaire may lead to different results when evaluated by different people. Besides, a person may change his view from time to time on the same concept. All these situations may occur when procedures are accompanied by questionnaires. A major negative aspect of using the audit is when the system gets used to their questions. This means that people know how to convince auditors on their questions to obtain positive marks.
Many clients force their subsidiaries to be audited according to the clients’ requirements, while their questionnaires have limited benefits for subsidiaries.

Dowling and Leech (2007), on investigating five auditing systems in large enterprises, concluded that although all firms view their audit system as a high enabler of the audit process, their audit systems were classified as low support systems for decision makers.

The auditor cannot frequently go for audits as it consumes time and money. The audit data is gathered long after the events are recorded. This causes a delay for preventive or corrective actions by managers at the scene. To prevent this in the financial audit system, auditors use the continuous audit system, which relies on the large data transaction (Thomas & Marathe, 2012). The outcome of such audits are always being quantified by dividing the number of total safe observations per total observation (safe plus at-risk observation), multiplied by 100.

2.3.2.4 Fractional Tools

This group of indicators includes some simple techniques used for data comparison or primary investigation.

(a) Benchmarking

To understand the performance of the operation or practice in comparison with other groups by using the normalized indicator, companies use the benchmarking tool. It can be used for comparison, internally, externally, and with competitors. Sherif (1996) used the benchmark for internal, external, and project comparison to evaluate a company’s performances, compare their productivity rate, and update their cost-estimation databases. Benchmarking in HSE is done at the industrial group and by using normalized lagging indicators. While it helps managers evaluate themselves with others, it could not help them improve their HSE performances solely or realize the reason for
their failures. However, many environmental, organizational, and social parameters may have an influence on the changes in the same situation of benchmarking.

(b) Cause and Effect (C&E) Method

The C&E tool aims to organize a network of causes and its effects. When brainstorming, a list of contributing factors toward an objective could be recognized while their interaction could be linked. This network may be used as the basic map for further investigation. However, there is no reason for the effectiveness of this map. In fact, it is just a preparation of a draft for further investigation and needs further study. The C&E helps managers in organizing and recognizing all the subsidiary elements that directly or indirectly relate to the outcome in a qualitative manner. If C&E is used on metric data within the same concept performance, it presents some kind of mass balancing. Figure 2.5 depicts an example of the C&E chart for a case of incidents that highlighted possible elements for further investigation presented by Sarazan (1990).

Figure 2.5: Cause and effect map for potential of incident (fall from height)

(c) Control System Charts (CSC)

Control Charts (Figure 2.6) are the other group of measurement tools that require a proper measure and proper context that represents the norm and variation of the measures. Therefore, it can be used for tracking any indicators; however, its use in performance management depends on the employed indicators. Average control chart,
Pareto chart, histograms, and run charts are different tools that may be used in this group.

![Average or “X chart”](image)

**Figure 2.6: Control system chart for an operational indicator**

(d) **Checklist/Check Sheets**

The checklist is a primary tool that guides operation and is used for data collection. It is used to understand that every element is in its right situation before any action. The check sheet is a record form for logging in repetitive data: quantitative or qualitative. The check sheet is designed for a specific purpose that needs no advance data interpretation. Checklists and check sheets are parts of every safety operation in the field; however, they provide a guideline for operators. Besides, each operation may have different checklists with designs based on different requirements and measurement subjects.

### 2.3.3 **Inclusive HSE Performance Measurement**

In contrast to partial performance measurements, which provide a general frame for data mining, the inclusive performance measurement refers to measurement systems that try to highlight an outcome of HSE performances. Turnbeaugh (2010) asserted that the company should have a proper frame to control their performance while the validity
of the performances should be controlled by other indicators. The outcome may be controlled by result base indicator changes such as organizational culture, financial, or throughput within the time frame.

The HSE performance measurement at an organizational level required a powerful tool to consider variation and the effectiveness of managers’ decisions about HSE. Evaluating performance as a result base indicator is ineffective in optimizing the process and not supporting positive changes in working objectives. Inclusive performance management addresses the overall performance of the entity, which may be done either by measuring the result indicator or modeling some leading indicators that present the HSE concept.

El-Mashaleh, Rababeh, and Hyari (2010) introduced different safety performance management techniques in his study, including 1- Data Envelopment Analysis (DEA), 2- Experience modification rating (EMR), and 3- Occupational Safety and Health recordable incident rates. Overall safety performance measurement is the other model that was introduced by IAEA to monitor overall business HSE performances. HSE culture measurement is the other result base performance that highlights the overall HSE culture of an organization.

2.3.3.1 HSE Culture Measurement

Different models exist to measure organizational HSE culture through questionnaires. One of the best organizational culture models was developed by Hudson and Van Der Graff (2002), and includes five levels of HSE maturity. They developed this model, called Hearts and Minds, based on different behaviors and managerial practices and in continuing the previous culture model introduced by Westrum (Hudson, 2007). The characteristics of organizational culture ranged from pathological as the lowest level of culture to generative at the highest level. Each level has typical
descriptions of its attributions. By answering 18 different questions, a person can identify the current level of his organizational culture.

HSE culture presents the long-term effects of HSE performance for enterprises. However, it is unsuitable to highlight the HSE performance of managers in the short term or be used as operational objectives.

2.3.3.2 Balanced Scorecard (BSC)

Managers formulate plans and are in need to have a system to implement and control their plans. BSC was introduced as a tool to link strategic control with management activities. BSC is a managerial tool that helps companies acknowledge its strategy achievement during the time. A company should set its strategy, set its objective to achieve that strategy, and then monitor its achievement. BSC aims to inform every employee on his/her contribution to the overall business success. This approach is matched with the HSE management system approach in a company.

Kaplan, Kaplan, and Norton (1996) explained four important business perspectives that should be considered in BSC. These four perspectives are 1- shareholders (financial perspective of business), 2- Customers (external view to company), 3- Business activities (internal strength of a business), and 4- human resources (business culture). The priority of third generation BSC as compared to traditional BSC is related to the strong linkage of the selected target with the long-term business strategy (Cobbold & Lawrie, 2002). The third-generation of BSC is the improved adaptation of the past four main perspective, which is updated to 1) financial and stakeholders’ expectations, 2) business organization and its culture, 3) business process and activity, and 4) external links and customers.

Financial benefit in the long term is different within business beneficiary in the short term (Gomes & Romão, 2013). According to Gomes, the balance between lagging and leading indicators and between financial and non-financial measures depends on the
strength of BSC. Limitations of the BSC include rigid measurement tools, which limit indicators to just four categories; a linear approach with no room for complex business processes; and limited innovation logic and lack of support for external innovation (Gomes & Romão, 2013).

Smack (2003) argued that the evaluation meeting on BSC should be set on a monthly basis rather than every three months. Within this concept, communication between managers would be concentrated on future progress instead of on what happened in the past. Moreover, he expressed that the board of directors require a higher-level report than department managers. Similarly, unit managers need to report with a more detailed view. According to him, a performance report network would increase communication and reinforce the link between the reporting team and organizational strategic report.

They replaced the safety objectives with business objectives, which is inaccurate. In fact, they have to define the proper HSE measures to link with the other BSC concepts toward business objectives. Defining a proper map between business objectives and organizational objectives is important in the definition of this system. Therefore, at the first stage, in gathering business managers, long-term business strategy and business objectives should be discussed and justified. At this point, the consensus of managers on the common plan is very important. Short-term objectives at the working level should then be assigned in line with business objectives. Rather than having a common plan between managers, organizations need to have an accepted measurement tool to determine how their desired results are being fulfilled.

Different researchers tried to adopt the BSC model to link safety (strategic objective) and its subsidiary objectives at managerial levels (Mohamed, 2003). However, there are many challenges in definition of a proper organizational map to link business HSE objectives to business HSE practice. As mentioned by Mohamad, it is possible to justify HSE objectives in four organizational measures needed by BSC; however, the problem
is the effectiveness of this linkage and finding a proper indicator to evaluate these objectives in practice. While this method does not directly support HSE, it provides a model to achieve the set objectives through selected HSE performance indicators.

2.3.3.3 Data Envelopment Analysis (DEA)

DEA is a software tool that models the efficiency of a system based on multi-input variables and multi-output variables. The model used in this software is adopted from the Charnes–Cooper–Rhodes (CCR) model, which is a linear mathematical model. Safety performances at the Jordan contractors were analyzed by Mohammad (2010) through DEA. El-Mashaleh et al. (2010) used this tool to evaluate the safety performance of 45 contractors. He studied the ratio of safety budget per business revenue as its input while the number of accidents with different consequences was set as its output.

DAE was not a safety performance model in the eyes of business management; however, it can help managers understand its productivities in terms of safety in comparison with the benchmarking (El-Mashaleh et al., 2010). Few challenges to DAE were found by the author: 1) It was established based on the models that could not discern the consequence of accidents. The outputs of this study considered five different types of accident which ranged from no injury to fatalities. However, a linear model simply aggregated the number of accidents without attention to their weights. 2) The amount of safety budget is considered by direct payment of the company to implement the safety program and its payment for safety officers, while these are some highlighted expenses from the company. Much extra budget was spent by managers, but its expenditure was not grouped under the safety-subject expenses (e.g., practices on remedial actions). It is difficult to segregate safety budgets away from other business budgets or separate energy costs from operations. This attribution will affect the accuracy of input data for modeling. 3) DAE model analysis highly depends on how
HSE performance is developed between input and output. Besides, it needs a wide range of data (from different cases) to import the model, which makes it unsuitable for performance evaluation of a single organization or in the short term. 4) The outcome of this model is extracted based on the annual data, which does not benefit the management decision during short time periods.

2.3.3.4 Experience Modification Rate (EMR)

EMR is employed by the US National Council on compensation insurance (NCCI) and the other insurer based on the amount of compensation they paid to the company (El-Mashaleh et al., 2010). In fact, EMR is a correction factor for insurance premiums. If it was 1.0, then the rate of premium will be the same as the industry average; however, greater EMR means higher risk and higher premium payment. Similarly, a lower factor means paying fewer premiums than the average company. EMR is a complex insurance formula and its usage was criticized in a different study by Kozlovska and Strukova (2013) and Hinze, Thurman, and Wehle (2013). The following are the weaknesses of using EMR:

1- It takes a long time for data generation and eliminating bad history

2- Data collected is regarding the average outcome within the long period of time (annually and three years)

3- The ratio of claim reserving practice is different among insurers.

4- It cannot be practiced in developing countries as insurance coverage is limited while full coverage insurance is not always purchased by companies. The compensation period by the insurance company may last for a few years.

5- The indirect effect of incidents, such as time and pain, is not involved.

Using EMR presents the result of poor HSE culture in companies through financial languages and could not be considered as a proactive business measurement to show the effectiveness of manager performances.
2.3.3.5 **OSHA Recordable Case**

OSHA Recordable Case is a network tool that helps companies report their incidents directly to OSHA in the US, which includes the fatal and nonfatal injury and illness related to the workplace. Injuries or illnesses are classified according to cases that lead to 1-Death, 2- Loss of consciousness, 3- Days away from Work, 4- Restricted work or light duty, and 5- Medical Treatment beyond the first aid. Then, the total recordable case (TRC) demonstrates the aggregated list of all groups (Lasowski, 2010). The rate of incidents in each group is calculated by considering the number of workers and the average of worked hours in each industry. These rates are published annually by BLS to inform industries for benchmarking its situation. There are challenges regarding the effectiveness of the requested indicators and its effectiveness to measure the safety performances (Amoako, 2013; Weiss, 2000). In fact, this system is a data bank of incident records for benchmarking, which might not benefit performance management at working levels. However, it would be effective information for strategic safety policy at the national level.

2.3.3.6 **Overall Safety Performance**

Overall, safety performances were developed by the IAEA for nuclear facilities to determine their safety performances. In 1999, nine countries accepted participation in a safety project with IAEA called CRP\textsuperscript{15} to develop and implement safety performance indicators in nuclear facilities.

\textsuperscript{15} CRP: Coordinated Research Project
Figure 2.7: IAEA safety performance measurement layers (Dahlgren et al., 2001)
According to Figure 2.7, safety indicators at the executive or operational layer are aggregated as strategic indicators and transferred to the organizational level. IAEA categorized safety performance indicators in three levels that cascade under a specific safety policy. IAEA grouped a variety of common safety indicators under a few safety indicators at the bottom line, and then aggregated these to build strategic indicators at the second stage. Similarly, these strategic indicators were classified into overall indicators. While the overall safety indicators were used to address specific safety attributes. The overall safety performance indicator is a dashboard calibrated based on changes in the strategic safety indicators for safe operation at nuclear facilities. Many introduced indicators are directly related to the nuclear facilities with a high level of safety integrity levels. They help managers track any deterioration at upper indicators through lower level measures.

CRP carried out much research to determine the lowest threshold for any introduced safety performance indicators. They classified the outcome of overall safety performances ranging from excellent, acceptable, and operationally acceptable, to warning acceptable, and non-acceptable regions.

2.3.4 Risk Base HSE Performance Measurement

Risk Performance measurement is the third category. It covered both partial and inclusive performance measurements if the measurement has involved based on risk. Risk is a general phrase that points to different concepts of uncertainty, hazard exposure, or chance of missing.

2.3.4.1 Partial Risk Performance Measurement

In recent decades, using risk is increased, especially in software development for technical modeling, decision support systems, and data mining (Islam & Houmb, 2010).

Kontio and Basili (1996) argued that the unpredictability of a situation interrupts managers’ decisions about normal operation and how they critically affect their decision
making. He also separated risk management from risk management knowledge as risk management knowledge needs more managerial information to attach with risk elements.

This section provides a short review of different indicators introduced by developers for performance measurement based on risk. Kloss-Grote and Moss (2008) had a critical literature review of studies with different risk performance measurements. He introduced a few studies that developed risk base indicators.

Kontio and Basili (1996) introduced two risk indicators, RCA\textsuperscript{16} and RCAAR\textsuperscript{17}, in the context of Riskit software development at Maryland University. According to a review by Kloss-Grote and Moss (2008), RCA and RCAAR indicators are helpful at beginning of a project but he did not mention his reasons. Analysis of Riskit by the author shows the usage of common risk management patterns, including four stages: 1) Classifying the identified risk factors and risk events, 2) developing risk scenarios between elements and events, 3) measuring risk effects for different scenarios, and 4) probability estimation for losses of different scenarios.

Kontio and Basili (1996) introduced another indicator called “Risk Reduction Leverage (RRL),” calculated based on dividing the quantity of risk exposure reduction per amount of risk reduction cost. The RRL indicator is applicable to limited scenarios of risk events and requires proper cost estimation by the advisor. It could not be used as a business performance measurement frequently; a wide range of risks exists in an organization each of which needs reliable data for its evaluation.

\textsuperscript{16} Risk Coverage Ratio
\textsuperscript{17} Risk Controlling Action Accuracy Ratio
The other risk base indicator developed by Anil (Anil, 2004 #318) is called RMPI\textsuperscript{18}, which is useful to identify the efficiency of risk management. Grote introduced RMPI in connection with software development owing to usage of Six Sigma within the multidisciplinary program. RMPI concentrated on risk identification within daily operation, which was one of the pioneer studies in this field. In another study by Cardona and Carreon (2005), RMI\textsubscript{IR}\textsuperscript{19} and RMI\textsubscript{RR}\textsuperscript{20} were developed under preparation of the disaster management program. While they developed these based on risk measurement, they could not be helpful for organizational performances. RMI is tied to disaster risk management at different levels, including global, national, and urban levels.

The other quantitative risk performance measurement was introduced by Olsson, called RIRR\textsuperscript{21}. Transportation was the subject of the software development project in their study. Olson introduced RMMI\textsuperscript{22}, which measured risk management maturity by using a checklist with three fields, including Database, Management and Reporting (Dahlgren et al., 2001). The maturity model was developed with the extension of Hillary’s research in 1997, based on credit and financial business risk. However, it could not provide a meaningful statement after implementation of safety (Kloss-Grote & Moss, 2008).

Maytorena (2007) introduced RIP\textsuperscript{23} as an indicator to identify the risk within the construction project in the civil engineering field. He argued that the process of risk management needs more attention in terms of risk identification. Proper risk

\[\text{Risk Management Performance Indicator} \]
\[\text{Risk Management Index for Risk Identification} \]
\[\text{Risk Management Index for Risk Reduction} \]
\[\text{Risk and Issue Reconciliation Register} \]
\[\text{Risk Management Maturity Index} \]
\[\text{Risk Identification Performance} \]
identification would impact on the success and power of total risk management (Maytorena, Winch, & Freeman, 2005). It consists in a loop of risk identification, risk analysis, risk response, and risk mitigation. Kloss-Grote and Moss (2008) argued that RIP was developed by Maytorena, expressing it was developed based on artificial risk identification data.

The author believes that many of the above-mentioned risk indicators would be suitable as a technical tool to evaluate the efficiency or reliability of the employed risk management techniques. However, they could not benefit from organizational performance measurement as they could not be integrated to generate an overall safety performance measurement. Therefore, in the following three risk measurement systems with the concept of the overall estimation of business performances discussed.

2.3.4.2 **Probabilistic Scenario Assessment (PSA)**

PSA mainly is not a performance measurement; however, it could be used for this purpose. In fact it is a measurement tools like Six Sigma or TQM but on risk base to recognize the probability of failure scenarios. By quantifying success and failure rate of risk elements within different situations and different scenarios, through mathematical methods could identify the number of weakness potential within design, operation, maintenance, and surveillance interval tests at a plant (Lee, 2013). The failure rates might be modeled by using different techniques, such as Fault tree analysis (FTA) or Event tree (ET).

FTA was developed in the 1960s by the US Air Force to test their launch controlling system and was applied to the nuclear industry after two nuclear accidents. The US Three Mile Island (TMI) nuclear accident in 1979 and Soviet Union Chernobyl accident in 1986 drew attention to PSA at design and operation of nuclear plant. While FTA is widely used, a new modeling tool called “Petri Net” modeling provided more advantages for PSA (Nivoliannitou, 2004). It also modeled time sequences of events in
addition to the time needed for modeling dynamic events (Lee & Lu, 2012). To use FTA, a case of top events would be defined in line with its subsidiary elements and related scenarios. Then, probability of failure rate on each component for each scenario would be estimated using mathematical techniques and the existing failure rate database.

PSA organization is constructed using three levels: 1) Assessing previous failures to determine frequency of core damages (this stage requires extensive data analysis and comprehensive databases). The second level of PSA depends on analyzing the controlling barriers in response to the failures listed in the first level. In level three, PSA assessment concentrated on estimating the consequences of any external accident in line with result of controls at level 2 (Ha, 2014). For example, if a plant is going to have special maintenance within Allowable Outage Time (AOTs), then the risk of unavailability of services should be calculated through mathematical calculation. PSA also is sensitive to changing the time, so by changing AOT, the risk calculation should be updated. Changes at trend of PSA would be an indicator for managers to understand: 1) safety level of facility at different operational situation and decision for better operation schedule; 2) safety level of plant at design or planning stage and identifying the area of improvement; 3) business overall risk monitoring over the time. An example of PSA output presented in Figure 2.8.

![PSA output by using a software of Risk Monster](image)

**Figure 2.8: PSA risk modeling outcome (Ha, 2014)**
Rather than difficulties in event scenario organizing and developing its linkage, probability modeling for measuring consequences and failures probabilities require the right information. Much requested information relays the history of failure rates of equipment or past events. In addition to these challenges, in nuclear plants, the probability of failure owing to human resources and their interfaces should also be quantified. Lee (2013) stated that using PSA would not eliminate the need for using engineering safety criteria, safety margins, or safety features. In fact, PSA just reviewed the overall risk of the scenario to find its potential for weakness in operation. PSA could not systematically cover human and managerial factors that play important roles in important incidents in nuclear facilities (Ghosh & Apostolakis, 2005). However, they are good supportive managerial tools for decision makers.

Szikszai (2001) introduced PSA as applicable to day-to-day operation if all its aspects come into practices for nuclear plants. Otherwise, it just might be helpful for limited and particular purposes. PSA used by most countries for design stage; however, in some countries with risk regulatory framework, PSA frame is in practices. Argentina, USA, Canada, UK, South Africa, Netherlands, and some Scandinavian countries historically used probabilistic approaches. Iran and Malaysia also use PSA in the design of their installations. However, they do not have risk base regulation.

Use of PSA needs to have additional deterministic requirements, such as central defense in depth, criteria definition for a single failure, or considering safety margins. Some common reasons for such requirements are immature probabilistic methodology, limitation of hardware and communication software, human behavior understanding, and physical phenomena. For this reason, instead of arguing the probability of concepts, the emphasis is on redundancy, diversity, and safety margins (Szikszai, 2001).
2.3.4.3 RMpass

While many risk management techniques exist to manage risk at the design stage, limited studies have been conducted on how to justify it to business risk. Maytorena (2007) expressed the weak point of risk management studies in companies on inadequate attention to proper risk identification. On the other hand, just PSA within introduced techniques looks at changes of risk in the identified scenarios. RMPASS is a method developed by Kloss-Grote and Moss (2008). RMpass tried to combine a risk management and knowledge management approach to determine operational hazards. Its concept has a proper foundation for risk identification as it covers two streams of risk, together: 1) the risk identified by experts, and 2) risk investigated from events. These two subjects demonstrated in Figure 2.9. It also tries to model risk transaction within time; however, it is limited to two windows of time.

According to RMpass, risk refers to the case of hazards identified and registered under risk management. If this case is identified later, it is called an event. Therefore, any hazardous case could be a risk or event or both depend on when it identified. The combination of risks and events creates three zones, called a) identified risk, but un-encounter event; b) identified risk and encounter event; and c) un-identified risk, but encounter events. Moreover, the risk zone can be divided into two subzones called mitigated and non-mitigated; therefore, zone (a) and zone (b) are each divided into two parts. The other concept integrated with these zones is the time dimension. Three time dimensions were assumed, including 1) time of sleeping, 2) active life, and 3) death (ending its time cycle). Within the first duration, risk was identified at the starting date, but this risk was not active until reaching the time “t” to become on operation.

At the time “t,” the risk becomes active until it reaches its time cycle end. Two opportunities face a risk before its death, i) it disappeared by termination of activities or ii) it leads to the event. The combination of these concepts created nine zones of risks in
the work environment. Grote segregated suitable mitigation action from risk zones at the sleep section to quantify the performance of a company. Overall, company performances on risk were classified into three categories: s) zone with sufficient mitigation, in) insufficient mitigation that is not possible (called β-mitigation action), and ia) insufficient mitigation that could have been possible (called α-mitigation action). Similarly, the whole zone of events, excluding mitigated, could be classified into in) insufficient mitigation that is not possible by its nature (called β-mitigation action), and ia) insufficient mitigation which was possible but was not done (called α-mitigation action). By applying these new classifications, the nine primary zones were raised to 17 zones.

Achievable Identification Efficiency (AIE) presents the ratio of events that could be prevented if proper risk assessment is in place. Its calculation is done by dividing the sum of identified events and predictable unidentified events by the total number of events.

The overall performance indicator in the RMpass model is measured using the Risk Management Performance Indicator (RMPI), while details of the model output were measured by Identification Efficiency (IE), Probability Assessment Accuracy (PAA), and Mitigation Efficiency (ME). All of these indicators ranged from 0 to 100%. RMPI was calculated by dividing the total beneficial case (number of sufficient mitigated cases, excluding sleep time) per total number of affected cases (all beneficial cases plus all could have been beneficial). Kloss-Grote and Moss (2008) stated that RMPI is just a number with limited information; however, it would be an indicator of how good the Risk Management was at the highest level. Identification Efficiency (IE) as the other introduced indicator highlighted what percentage of events could be estimated before, by doing proper risk management. It is calculated by dividing the total number of identified events by the total number of events.
Figure 2.9: RMPASS model components (Kloss-Grote & Moss, 2008)
Probability Assessment Accuracy (PAA) presents how well the estimated occurrence rate is matched by the actual occurrence rate. Mitigation efficiency (ME) as the last indicator in RMpass would be generated by dividing the number of beneficial mitigation (excluding the sleeping zone) by total mitigation, whether sufficient or insufficient, excluding the sleeping zone.

The introduced indicators excluding RMPI are a sign of how effective or valid was the risk assessment, while RMPI could be an indicator of project management in terms of HSE. RMPI demonstrated how well mitigation plans have been done in projects, which is helpful for managing. Besides risk identification by focusing on experts’ idea and by events presents wide risk identification. Moreover, the time dimension as an important factor, being assigned to risk management.

There are some challenges with RMpass according to the author’s experience. 1) Process of risk and event analysis, conduct non-continuous. 2) The risk level at the non-mitigation zone is considered no risk, while the risk existed at a less than acceptable level. No risk could just be used when the case for creation of risk is eliminated completely. 3) A risk that ended an event does not necessarily mean that it finished its time cycle and it might still exist, while RMpass considered no risk. 4) The difference between non-mitigated risk and mitigated risk is significant if it ends with events; however, it also would be significant within non-occurred events during the time and might be happening. 5) The output indicator calculated just based on the number of identifying cases without attention to its risk level. The case with different risk might have variations in their impacts. 6) IE calculation was conducted based on the number of events, while the event is not a good unit for this purpose. If they replaced the number of identified issues (hazard case) with the total events, it provides a better estimation of this factor. The reason is that one event might be laid on one or many hazardous causes.
2.3.4.4 Hazard Cloud System (THP & MHP)

The Hazard Cloud system is a data integration system based on the cloud sharing system in terms of HSE performances. The author found this system very useful to monitor safety performances, especially operation and construction activities. While different risk assessment methods were developed to control the risk one by one for each subject, this system provides the overall hazard potential assumed in each subject, such as the project, installations, area, etc.

Total Hazard Potential (THP) and Mitigated Hazard potential (MHP) are two risk-based indicators that have been reported and integrated with the hazard cloud system since 2009. These indicators were used for the first time by the Iranian company, IOEC and Tidewater Middle East Company. However, its theory is under development. In Persia, they called this system a “Hazard Cloud System” in which the THP and MHP are two basic indicators. THP presents the size of hazard cloud in which the MHP illustrated the amount of safe mitigated hazard cloud. Similarly, RMPASS identifies hazardous cases through primary risk assessment or by analyzing events in line with operation, but not limited to them. The Hazard cloud system is constructed based on all reported unsafe acts or unsafe conditions. By contrast, RMpass attempts to monitor any risk at two stages of time: \( t_0 \) and present time. The Hazard Cloud system moves on the continuous time line. In fact, any unsafe conditions and unsafe acts have their own life time cycle.

The unit of measurement in the Hazard Cloud System is HazPoC. This metric is the foundation of the Hazard Cloud System, discussed later. The Mitigated Hazard Potential was calculated based on changes in the amount of HazPoC existed under THP. This mitigation may be carried out by doing a remedial action, corrective action, or
corrections of unsafe acts/conditions. In fact, MHP presents the business commitment to control THP by employing different barriers that may perform at the altered time. Ratio of MHP to THP provides an estimation of past HSE performances and illustrates the distances from standard for future road maps. Companies may set the ALARP level rather just looking at the standard level set for others.

The assumption in THP set the probability of event occurrence, $\Theta$, independent of $\gamma$. The probability of events resulting from each hazardous case was raised from zero on the first day to one, in which the first event occurred or was probable to occur. In fact, the hazard potential of a case will increase from the first day and reach its highest at the probable day of the first event (whether it occurred or not, based on database records).

HazPoC is the unit of measurement for the change of the hazard potential. HazPoC was developed by the author for the first time in 2009 as the combination of three phrases: Hazard + Potential + Case. One HazPoC refers to one level of risk of a hazardous case for one exposed person during 8 hours (one working shift). Hazard potential of a hazardous case would have been varied by changing the exposure time, level of risk, and number of exposed people in a dynamic working environment to one hazard type. Total hazard potential refers to accumulated HazPoC resulted by different hazardous cases from activities, resources, and environment regardless of it having barriers or not. THP calculated on daily bases then might be reported as the average of weekly or monthly for each task, activities, process, departments, and each working premises.

Changes in working or operational conditions would lead to changes in the amount of Hazard cloud in companies, projects, or departments, as illustrated in Figure 2.10. The Hazard Cloud System is the combination of the hazard potential of all hazard cases (phases) at the first level. In an organization, the hazard cases computed are based on five groups (first level), including: 1- workers (people), 2- machineries and equipment,
3- working area and facilities, 4- functions and material, and 5- subsidiaries (companies), which would be nested by the primary four elements. For example, hazard clouds at the people phase in the second level is the combination of hazardous clouds nested on their segment segments; such as PPE, competency, and training for workers.

The life cycle of the implemented barriers might be ended earlier than the hazard case life cycle. Increasing the number of barriers on each segment would increase the amount of HazPoC under the MHP; however, MHP could not reach above the amount of THP.

Mitigated Hazard Potential (MHP) refers to the amount of HazPoC being controlled by implementing any barriers. This control could be reached by declining the risk level or minimizing the number of affected people or by decreasing the exposure time. According to the HSE system in the Tidewater Middle East, the MHP measurement unit is the same as THP and is reported based on HazPoC. One HazPoC of MHP is equal to eliminating “one risk level of a hazardous case for one exposed person on one day.” MHP is measured daily and reported as the average of weekly or average of monthly.

Hazard cloud of an organization or a company was constructed based on the amount of hazard cloud at its departments and subsidiaries. In a similar manner, the hazard cloud of each department at the second level was made based on the amount of hazard cloud of five different elements, including people, equipment, working area, operational functions, and third parties. Each of these elements (called phases) also may include different segments. For example, different types of machineries from light to heavy vehicles can be organized under the equipment phases. Each of these segments also may be evaluated through different risk categories (called vectors). For example, safety risks may have different vectors, such fire risk, electrical risk, etc. So, the hazard cloud of a company can be calculated based on different vectors at different segments or at each segment or within each phase or under each department. On the other hand, a company
may prefer focusing on the hazard cloud at the segment level or above. No matter what level a manager looks at the hazard cloud, he or she must prevent aggregating the hazard clouds of one department at a second level (phases) with the hazard cloud of the other department at the third level (segments). In fact, the hazard cloud investigation has to follow the same strategy as the company.

Figure 2.10: HazPoC flow, data integration at the Hazard Cloud System
MHP in IOEC\textsuperscript{25} is reported on two different concepts: 1- Pointed MHP or daily MHP as a central tendency which emphasis on how much the average hazard potential might be eliminated on each day. 2- Bulk MHP that shows the total amount of mitigated HazPoC within a time period of an operation or activities. Because of delay in decision-making for risk mitigation, the starting date at MHP measurement might be different by the initial time used to measure the THP for each hazard case.

No matter what HSE risk matrix was employed by a company in their system, the HSE performance of a manager is acceptable by comparing THP and MHP, both as reported based on the HazPoC unit. However, benchmarking needs a similar matrix.

According to the report by developing team in IOEC, the theoretical and conceptual basis for the THP methodology was grounded in probability statistics, in which

- The probability of each occasion (positive or negative) from a hazard case will not be 0 and 1, but depends on the risk level of the case. So, a binomial distribution could not represent the output based only on success or failure.

- Each hazardous case is a discrete and independent experiment, which may perform frequently of n series of usage. Thus, the probability of each case of performing n series is $0 \leq p(x1) \leq 1$, and

- Each case has the ability to create its danger based on amount of its hazard potential (HazPoC).

- Each event scenario has a specific Hazard Cloud that resulted by aggregation the hazard cloud of its unsafe conditions before applying barriers. More phases and detailed segments lead to greater clarity.

\textsuperscript{25} Iranian Offshore Engineering and Construction
• Each case either in the first or the second levels may have different risk groups (vectors). Therefore, each case may be reported few times through different vectors (electroshock, fire, asphyxia, et cetera.)

• Total hazard potential should be aggregated within the same level. Integrating the cloud at different levels may lead to an unjustified result.

• To eliminate the uncertainty of a person’s judgment on risk estimation or the gap of undiscovered unsafe conditions, and unsafe acts, the probability of THP must be adjusted in the frame of one result base indicator and within normalized working hours.

2.4 HSE Indicator

Milne stated that people can manage some tasks without its measurement, but that they could not improve it if it could not be measured. Yusuf (1999) stated that, to promote workers and managers to the business goal and to raise their commitment, they have to be able to measure their performances at the operational level by themselves. Different performance measurement systems were discussed to help managers evaluate their responsibilities partially or overall. However, usage of any of them needs to have effective HSE performance indicators. PSA, RMPI, THP, and MHP could also be one of the indicators used by companies, which were introduced earlier.

2.4.1 Indicators Classification

In this section, a review has been done on how performance indicators may classify different research to find out the specification of indicators that benefit companies for their performance management.

2.4.1.1 Formative and Summative Indicators

HSE performance indicators, like other operational performance indicators, can go through formative and summative evaluations. If the manager is interested in improving the HSE, along with other functions, he needs to use formative evaluation. On the
contrary, if the evaluation of HSE performance in the department was set as the goal at the end of operation, so summative evaluation would be employed. An example of formative decision-making of Malaysian Occupational Health and Safety is changing at the number of companies who implemented the Malaysian OSH standards or changes in the number of injuries reported to them. At the end of a season, formative data will support summative judgment about the safety performance in the whole of Malaysian industries during that time. For example, the ratio of total recordable case of injury per 10,000 workers at the end of a year could be a summative evaluation for the Malaysian government. Bennis (2004), in his book, mentioned that, to measure the performance of a system, employing a single measurement of output is not reliable and both formative and summative indicators are needed for effective measurement.

2.4.1.2 **Lagging and Leading Indicators**

While these two phrases (formative and summative) are generally used in training systems, OGP or many other Safety and Health organizations classified indicators on this concept within two groups called Lagging and leading indicators. Lagging Indicators are equal to summative indicators and leading indicators have the same function of formative indicators. The fluctuation of data on trends of leading and lagging series in economic field was defined by Moore (1969) and by John Merriam many years ago. He emphasized the following:

\[
\text{The value and validity of observation that peaks in leading indicators series are often preceded by troughs in lagging series and the that trough in leading indicators series are often proceeded by peak in lagging series, depends on the variability of these sequences.}
\]

Moors explained a causal connection running from leading to lagging series.

According to the OGP definition,
KPIs which record actual integrity failures are typically called “Lagging Indicators.” By contrast, “leading indicators” can be used to assess the health of the safeguards and controls which make up the barriers.

With the other perspectives, one indicator could be nominated as either lagging or leading, depending on the perspective of the judgment. For example, an incident indicator considered a lagging indicator for the company could be seen as a leading indicator the industrial level for strategy makers.

In organizations, a combination of proper leading and lagging indicators should be managed by the collaboration of different organizational levels. In today’s business, poor contribution of the entire organization hierarchy has linked to inadequacy of proper measurement (Army, 2012). He mentioned the following:

_to make this (proper measurement), it should be applied (applicable) to all levels of organization...and personnel should feel responsible and held accountable for end result._

Moreover, the judgment based only on result base (lagging) indicators are inappropriate unless they are joined with the proper leading indicators (Army, 2012).

2.4.1.3 **Subjective and Objective Indicator**

Franceschini et al. (2007) classified indicators to subjective versus objectives, or single versus aggregative, or basic versus derived indicators. Objective indicators refer to counting or measuring special objects through empirical analysis that is independent from its subject. For example, the number of producing products is independent of who measures them and is objectively connected to the symbolic manifestation. So, different equipment or people would measure it with the same result if they had no counting mistakes.

Subjective indicator: The result of measurement is dependent on the opinion of the subject who did the measurement. So, different equipment or people might create different results depending on who plans or maps the measurement of the title. For
example, evaluation of a car design might be planned through different concepts by different people. In fact, for subjective indicators, there is no basic unit of measurement; therefore, every person plans it alone.

According to the classification provided by Franceschini et al. (2007), most Safety and Health indicators are always subjective indicators in which every company, organization, or person defines it from a variety of perspectives and with different specifications. For example, measurement of the safety culture, safety climate, or risk calculations is of some concern, closely studied by social and behavioral psychologists and cognitive scientists. However, some part of safety and health that goes back to the measurement the temperature, pressure, or chemical reaction goes under objective measurement by technical tools.

2.4.1.4 **Single and Aggregated Indicator**

Single indicators are representative of variation in a single measured topic. The aggregated indicator points to a set of indicators that represents the whole system performances within few concepts. According to Franceschini et al. (2007), it is not true that in complex systems or in specific macro-portions, the performances are presented by integrating different concept of performances into a single indicator through an algorithmic relationship.

HSE concept is a complex and specific macro-portion, which includes safety, health, and environmental concepts. Besides, it could be considered from a different point of view by different managers and also by different subjects. Health, safety, and the environment are three different fields. Technically, however, they generally have overlapped and could not seen as three independent concepts by business managers.
2.4.1.5 Basic and Derived Indicators

Basic and derived indicators are defined by Franceschini et al. (2007). A basic indicator refers to the indicators extracted from direct experiments at different concepts of observation as a thick block. HSE indicators, for example, number of deaths, fatalities, accidents, and pollutant concentration at the release point, could be basic indicators. Derived indicators are those obtained from information on other indicators, whether basic or derived. Many extended or contractual indicators are categorized under this group. For example, a company, who measured LTIF, obtained this by integrating the two groups of lost time incidents and number of working hours. Figure 2.11 presents an example of pollution index as part of environmental measurement (Franceschini et al., 2007)

\[
I_{TOT} = \max \{I_{NO}, I_{HC}, I_{CO}, I_{PM_{10}}\}
\]

**Figure 2.11: Environmental basic and derive indicator**

The way companies integrate their basic data to generate new derived indicators are varied and almost challengeable. Different models might be used for this integration while an extensive methodology is needed to control the reliability and validity of new derived indicators. Development of any new derived indicator should also be conducted based on the proper mathematical approach and validity control through empirical analysis and sensitive analysis.
2.4.1.6 Synthesis and Overall Performance Indicators

Synthesis indicators are a set of basic or derived indicators that present different concepts of a subject for decision making. Performance dashboard is always used for this presentation as a tool that demonstrated a small number of indicators in a panel. In synthesis indicators wide range of other indicators was compressed in few indicators to demo. Franceschini et al. (2007) introduced three approaches synthetic indicators might be selected based on. This synthesis would be conducted through 1) the “relative importance” concept, which provides a synthesis based on the importance of indicators toward targets; 2) “minimum set covering;” and 3) “degree of correlation.”

In a nuclear plant in Sweden, technical safety indicators were reported by aggregating different safety subjects; however, they might be reported separately. Nuclear facilities have two specific indicators: fuel performance and collective radiation exposure. Rather than technical indicators, they employed organizational issues and safety culture indicators (Cervin, 2001).

The overall performance indicator is an aggregation of different indicators to produce a new indicator, which represents the overall situation. For example, air pollution index is an overall performance indicator that presents the overall condition from subsidiary measures. It is developed by the integration of some basic or derived performance indicators. According to Dahlgren (2001), the participatory approach requires that all management levels and supervisors actively participate in the definition and deployment of meaningful safety indicators. Functional levels are in charge of performance of facilities, machines, and lines, consumption of materials, energy, and resources; however, at the strategic level, managers need to understand the overall outcomes at different concepts (Ciemleja & Lace, 2008).
2.4.1.7 **Driver and Result-base Indicators**

Results-based indicators were used in many researches as a way to compare the performances of industries and to benchmark by others. It represents the outcome of the measured concept at the broader concept. Results-based indicators are reactive indicators that do not change when they are reported. They would be built by known or unknown reasons and stress results.

A driver indicator is a single or an aggregated indicator in a concept that addresses some specification of the concept. It drives the manager to change its direction or speed to adjust the concept to its objective. A driver indicator is proactive indicator that motivates its organizer to improve.

Owe (2005) classified the business performance measurement into two categories: 1) Results-based indicators, which are the same as the business context outcome; and 2) business drivers. He classified business drivers into two groups of operational drivers and strategic drivers: 2a) operational drivers, designed and implemented in field operations to manage the performance of operation, data transaction, maintenance of flow, and supervision and 2b) strategic business drivers, for planning and development of the long term strategy of business. They are essential tools for estimating the future and analyzing the past records and achievement.

He stated that within a business framework, 80% of senior manager's tasks are passed through strategic drivers and just 20% are consumed by operational drivers. By contrast, one operational manager or team leader reports cover 80% of operational drivers and just 20 % of strategic drivers (Ow, 2005).

2.4.2 **Indicator Organization**

It is assumed that indicators follow the managerial hierarchy in organization. In fact, by changing the organizational level, the need for data is changed. Therefore, the same measure could not be employed rigidly (Cable et al., 2005). He stated that the objectives
in private sectors are different from those in federal or other governmental organizations.

Fang (2001) highlighted that the use of safety performance indicator should be integrated with the business plan and organizational culture. The industry is responsible for answering both regulatory and profitability. Safety performance indicators should be understandable for managers and even laymen (FANG, 2001)

Line managers and supervisors have a great influence on the safety behavior of subsidiaries if they are involved in the weekly feedback of safety performance (Zohar, 2002). Continuing his research, Juran (2005) classified performance measurement in organization into four levels. At the bottom level, he introduced technological measurement systems that monitor part of activities or services. Most measurements at this stage are basic data. At the second level, indicators synthesize first level indicators of that process, services, and activity. At the third level, he introduced indicators presented a concept at that sector, lines, and services by synthesizing the previous indicators. At the top level, top managers used overall or synthesis indicators to evaluate overall business performance.

The safety authority governmental organization is looking for overall services to the public at the highest level. Employing the same indicators might not be effective for all groups. Cable et al. (2005) emphasized that developing Key Performance Indicators at federal and governmental organization should be addressed by private sectors.

2.4.3 Indicator Specification

Managers required having proper indicators to carry out their supervision. This specification has two layers: 1) time specification, called time interval of indicator; and 2) quality specification, which refers to the attributions an indicator is supposed to have to be effective. Discussion regarding time interval is presented in “Time section”
ar 2.5.2 while the Malaysian indicators time interval is calculated in section 2.6.4. Therefore, this section just discussed regarding quality specification of indicators.

Arveson (1998) mentioned some specification for KPIs, including being: Leading indicators, Objective and Unbiased, Normalized, Reliable, Unobtrusive, Cost effective, Multi-perspective, Appropriate to the subject, Accumulative and quantitative, Efficient and comprehensive, and Discriminating with meaningful concept with small changes. Cable et al. (2005) added three further specifications to this list: Action oriented, Understandable to managers, and Verifiable. Safety performance indicators should also be understandable for both technical and non-technical parties, facilitating communication between safety and other business attribution and performances (IAEA, 2000).

There is no classification or grouping of indicator attribution; however, researchers just try to mention as much specification as it might have. For example, Dahlgren et al. (2001) list 13 characteristics for indicators: 1- direct relationship between the indicator and the subject; 2- access to required data or opportunity to generate that data; 3- being quantitative form; 4- not be ambiguous specification; 5- having meaningful significance; 6- Not generate based on data manipulation; 7- manageable; 8-meaningful; 9- Validated; 10- practicable for normal operational activities; 11- Address the cause of failures or deficits; 12- Accuracy of data can be controlled and verified at different levels; and 13- promote local action.

In USA, the Nuclear Reactor Commissioning in its safety indicator development program stated some important specifications of the research team in accordance with suitable indicators. The suggested specifications for a performance indicator for supervision should be risk base, understandable, predictable with a clear objective for measurement, while its frame should be top-down hierarchical approach (Dean, 2001).
NRC defined six components for performance measurement specifications: 1- Limit initiating events, 2- implement reliable, capable mitigation system and keep it available, 3- ensure of safety integrity between barriers, 4- prepared proper and adequate emergencies, 5- protect publics and workers from dangerous exposure, and 6- assure of effectiveness of safety barriers (Dean, 2001).

The author assumed that a suitable key performance indicator should have the following specifications:

1- Track changes: Help managers to monitor changes in details for a safe operation whether the company decided to publicize its performance to others or not, while it helps each group monitor itself before being judged by the upper manager.

2- Produced by contribution of all: Monitoring changes of safe operation is not the sole responsibility of the HSE department, all managers need to care and implement the corresponding HSE activities like other management tasks.

3- Time reliability: Safe operation is a frame of doing any task and any job safely, so a reliable safety indicator should support the continuous operation. Time reliability is essential to make a proper communication frame.

4- Integrity with the other management layers: A suitable HSE KPI could be directly linked with other business management layers internally. It needs to be connected to the line managers at the front line of an operation and keep this connection to the CEO at the highest management rank for strategy planning. Furthermore it could be reliable to connect with contractors at the bottom line to the board or client management groups.

5- Have a significant relationship with result performance indicator: The outcome of strategic performance indicator shall be adjusted with result performance
indicators. Any deviation between HSE KPI and the result base indicator will highlight the errors, which exist in KPIs.

6- Constructed based on operational drivers: According to the Owe (2005), the HSE KPI should have the potential to link with HSE operational drivers.

7- Measurement must be positive, preventing negative impact.

2.4.4 Data Issuance and Concern

Raw data is known as crude information, but it should proceed to become knowledge in itself. During this sequence, data would be changed to information, fact, and finally, knowledge. For decision-making in organizations, managers need to have information or reliable data to process. Transition of data to information happens if it is relevant to the decision subject (Arsham, 2012). Information becomes fact, if there is sufficient evidence to support it. Further, on passing successful completion (statistical degree of confidence), the fact will become knowledge.

CSP organization in the US gathered statistical data of the labor force through approximately 60,000 samples per month across 31 states. Type and rate of unemployment are some criteria in this survey with 95% of confidence. The sampling is designed for the state bases, but it revised based on state population size to maintain the required reliability of data. The ratio of sampling across each state is ranged from 1 in every 200 sample population to 1 in every 3,000 samples which is repeated each month. Considering different adjustments at the data collection, CPS declared that “although the sampling is a state based design, the sample size of the CSP is sufficient to produce reliable monthly estimates at the national level only. Their samples do not permit the production of reliable monthly estimates for the scale.” Decisions by managers in companies are often made without evidence and are sometimes based on a manager’s feelings. It has been argued how reported HSE indicators in performance reports may be based on no evidence in practice.
Two very common safety performance indicators are rate of death and rate of injuries. OGP normalized these based on special amount of time (rate of deaths per 100,000,000 working hours and total recordable case of injuries per 1,000,000 worked hours. In the UK, the rate of fatalities is reported per 100,000 workers, which is equal to 200,000,000 working hours). The US Bureau of Labor Statistics (BLS) mentioned in their report that the incidence rate regarding illness can be reported based on every 100 workers (instead of 10,000) by moving the decimal point two places to the left and rounding the resulting rate to the nearest tenth (BLS, 2012).

What is the meaning of these numbers and how do they affect managers’ decisions in companies? Assuming that the number of full-time employees in an SME is 15 and just one occupational illness/injury was reported during the last working year, the incidence rate would be 670 per 10,000 employees or 6.7 per 100 full-time employees. If this company had no injuries during the last year, then this rate would be zero. In fact, fluctuation in safety performance indicators in terms of TRC of this company after a year would change from 0 to 670 or 6.7 (depend on normalizing factor) by only one incident case. In this company, regardless of the consequences of an incident (a fatality or medical treatment case), the “total recordable case per 100 full-time workers” would be 6.7 per 100 full-time workers. In case of zero incident, a manager has no record of performances. After the occurrence of the first incident, its injury rate jumped to 6.7 for this example. Could this indicator be a good measurement tool for a manager to monitor performances?
Figure 2.12, adopted from a real case, presents the HSE performance of an organization that worked 300,000 man-hours per month. If each worker worked ten hours per day, and 20 days per month, at least 1500 workers were needed to support 300,000 worked hours per month. This huge population represented a far difference between the company and SMEs or large companies with 200 workers. When the amount of indicator for 1500 workers fluctuated partially, it did not benefit the middle managers, who supervised 15 workers. According Figure 2.12, TRC frequently changed in the performance report of company with 1500 full time workers from 0.5 to 3.7 while LTIF fluctuated between 0.2 and 1.3. As a matter of fact, if the number of incidents does not change while there are changes in the number of workers, then this indicator is prone to change.

The other problem with using the same lagging HSE indicator is related to the measurement of the health topics. Occupational health indicator in an organization is of the latency period of illnesses. So it is difficult to find an association between illnesses and work; it is difficult to compile a complete count of all fatal illnesses in a given year. Thus, information on illness-related deaths are excluded from the measurement by companies for their business.
2.5 **Time Importance**

Business is looking for optimum efficiency and maximum success in contest with other competitors. Managers try to balance business resources and their objectives within the management network. Time is a hidden layer extended in line with all business activities, decision making, planning, investment, and performance assessment.

2.5.1 **Time Definitions in Business Management**

Time was an important element in the management of any business components locally or in connection. In this section, the author provided a short review of different definition of time usage in companies, which effects HSE performance management. These classifications are presented by reviewing the time definition used in different studies.

2.5.1.1 **Just in Time-window, Norm**

In 1988, the Just-in-Time phrase is used to eliminate all waste from the entire performances of businesses in supply chain management by Frazier et al. (). Companies always desired to minimize their operation time while this minimization affects business sustainability. Time optimization is the better phrase, which should be substituted for time minimization. Time minimization beyond the allowable time would enhance the level of hazard risk at operation. Therefore an allowable time of operation nominated “operation norm” that allocate a reasonable time to process an enough amount of operation.

Today, by employing more advanced technology, modern communications and decision support services, time being saved for more cost-effective operations. Lack of a proper time window for operation imposes a significant unsafe condition on the activities and affects all participants.
2.5.1.2 **Response Time**

Time under the concept of response time addresses how fast any decision would be made, whether in normal or emergency conditions. In contrast to time windows, which look at the overall time for a process, response time back to the overall time needed by each of components of the process. In fact, information that is needed for a decision would be made at the nearest time to minimize the probability of mistakes by getting final data quickly. Decreasing the response time also is understood as a basic requirement to decrease the Just-in-Time window. Time plays a critical role in decision-making in Safety Instrumented Systems (SIS). Different control systems may be implemented in instrumented systems to manage risk during the time on probable failure mode. A variety of standards, such as ANSI/ISA-S84 or IEC 61508, IEC 61511 are developed for these purposes. If the first safety barrier missed in the operation, the second control layer would come into practice automatically within a time frame. Different layers of controls also may be designed in a process to handle the risk of the operation, such as programmable logic controllers (PLCs). However, its performance would be functioning within the proper time frame. Therefore, any improper time adjustment or time shortage would be considered an unsafe condition for systems.

In addition to the response time in process safety, response time may refer to the time needed by emergency teams to control an event. In many cases of incidents, an emergency response team is employed to minimize the significant impact resulting from accidents. Time for emergency responses again look for minimizing any more damage by incidents. Evaluation of response time always has been done to understand the performance of the emergency team.

2.5.1.3 **Time Scheduling**

Time scheduling is a common practice in business planning. Scheduling should be done by respecting the business norms and unpredicted conditions in line with working
plans while the schedule tracking presents how business move along with the plan. Changes in scheduling would affect other business risks, such as financial and HSE risk.

2.5.1.4 Time Estimation

Time estimation is the other concept of time that predicts future trends based on time trends in the past through linear or nonlinear models. This concept is used for prediction of changes or overall estimation of a subject in the timeline. Reliability and validity of estimation is depending on the power of model and validity of input data. Time may be used as a factor in critical modeling for technical purposes.

2.5.1.5 Time Integrity

Time integrity is the other important concept of time used for data alignment between different tasks or concepts. It could be used for risk integration, performance management or process safety integrity. For example, the HSE risk level at the design stage almost sets a different failure rate based on the SIL. This integrity level should be maintained in the design of the other in-line operations as well in the short term. On the other hand, time integrity would be a foundation for HSE risk integration in the long term. The gap in time integration stated by some researchers as safety failures in operations. Either lower or higher risk levels without attention to basic risk level would waste business resources. Decreasing the safety levels over the long term is reported in incident investigations; for example, in the leak of Isocyanine gas from the Union Carbide’s pesticide factory in 1984 which killed more than 2,000 people and injured an additional 50,000 people in Bhopal, India (Barry, 1985). This was because of neglecting the balance of risk over the long term. Poor maintenance of safety systems raised the risk levels of the company in comparison to the risk level for which it was designed (Gruhn, 2006). On other side, replacing devices with a higher safety level instead of using equipment in a non-dangerous area, increased the business cost with no
improvement in the overall safety (Oktem, Seider, Soroush, & Pariyani, 2013). Aging is the other concept of time integration, addressed by Coleman (2011).

2.5.2 Time Elements at Performance Communication Network

The performance report consists of graphs, text, and summary of its analysis of indicators (or measure), which demonstrates the present condition in comparison with the past and highlights distance from the norm for future planning.

2.5.2.1 Indicators and Time Interval

Indicators have specific Time Intervals that present mean time in which one record of the subject is likely to be logged. This record could be positive (e.g., Lack of incident) or negative (e.g., Incident occurrence). Two groups of Time Interval exist: 1- Fixed Time Interval defined by contract; 2- Temporary Time Interval that its occurrence changeable depends on situations. For example the “worked hour” or “fatal occurrence” are two different indicators. “Worked hours” indicates the amount of time spent by human resources for the special task of business, while “fatal occurrence” represents losses on its human resource. Time Interval for “worked hours” is “one hour,” which is a fixed Time Interval in any situation. By contrast, time interval for fatal occurrence is temporary and susceptible to changes in different situations. Time Interval for fatality would be the mean time at which one fatal incident is likely to happen, according to past experiences. Managers need to use different indicators with different time intervals to control performances. So, it is necessary to set up a proper time frame for arranging them.

2.5.2.2 Periodic Report and Time content

The periodic performance report refers to an official progress report that is supposed to be reported frequently by managers. “Frequency of reporting” or “reporting cycle” is the minimum cycle during which a manager can afford periodically to collect data from subsidiaries. The time content of a report are the important phrases that were built on
but not limited to frequency of report. Actually, time content of report represents the combination of workers’ population and the time duration of the report cycle.

Time content of a report plays a ceiling role for Time Interval of indicators, which is embedded in that report; however, they are independent from each other. Managers are allowed to collect performance reports at different cycles and to ask for any indicators they want; however, they have to be aware of time reliability through the ceiling role.

Measuring the time content of a performance report depends on the working schedule of the organization. In fact, the time content of a monthly report in the company with a schedule of five working days per week is different in the same company that operates seven days per week. The number of days will be changed from 20 worked days to 30 worked days per month, creating change in the time content of their performance report.

2.5.2.3 Periodic Report in Dynamic Performance Network

The time content of a report is an essential time frame for selection of performance indicators by a manager. It would help managers to determine their managerial needs as a static concept in the business performance network. A dynamic concept of the business performance network requires that the time cycle of reporting at different managerial levels be adjusted to one timeline. The time line is a series of non-stop days, which can start from a contractual date and be used for this alignment. The periodic report expresses data gathered over a fixed time period (cycle). To prevent loss of data because of the gap in time integration between calendar time and reported cycles, moving on a timeline is essential for managers of the organization.

2.5.3 Time Criteria for Decision Making

Criteria for decision-making in management differs from the statistical criteria required for professional research. In statistics, for a reliable conclusion at least 15 observations are needed for a sample population, of which skewed or outlier data will
be excluded (Elliott, 2007). Researchers look for extensive data analysis in their research; however, in a business, managers are free to take any decision regardless of its validity. This section argued for the minimum criteria for managerial decision making.

Safety authorities defined performance indicators as a ratio of the number of events per fixed time of exposure (Duffey and Saull 2003). For example, the rate of LTI occurrence in industries might measure per amount of one million worked hours. The ratio is a continuous number with any number of digits in mathematics, but in practice, digits are not meaningful. Duffey and Saull (2003) stated that a measure of safety experience should be meaningful, openly recorded and consistent with other data collected from other areas. Regardless the type of indicator or its event rate, at least one complete time cycle should pass to understand what occurs in the time frame. Time reliability criteria point to the time duration, of which at least one case of measured subject will probably be measured. For example, LTI rate of 1 per 1000,000 worked hours is reliable for use in business or working groups with 1,000,000 hours and above. Thus, safety performance in smaller rates is meaningless unless the company reaches one million hours. Manipulating digits according to working hours is merely a mathematical game by time that is not related to safety performances.

Time content of reports is constructed based on the amount of the worked hours yield by the number of workers over the period of reporting. On the other hand, time intervals of indicator are constructed based on the amount of time needed to record such evidence. In a company, if the number of workers is assumed to be constant, then the period of reporting could be compared over the time interval of the indicator.

Figure 2.13 illustrates the frequency of reporting and the Time Interval of the indicator. It demonstrated three situations of alignment of time cycles between the period of the report (one cycle of reporting) and Time Interval of the involved indicator. If the Time Interval was shorter than the report cycle, we have more evidence for
decisions on that report, Case (a). Second, having equal cycles between the period of the report and Time Interval forms just one piece of evidence for the decision (case b). In the third state, the cycle of reporting is less than the time interval needed for such evidence, Case (c), which is the immature and meaningless case. It is wrong to report immature cases as evidence.

The literature review highlighted no previous studies in terms of time reliability of safety indicators, nor in the other field of measuring managerial decisions. Therefore, the author calculated the time content of safety performance indicators in a separate section while discussion regarding the suitable time frame was investigated as a separate objective in this research.
2.5.4 **Time Interval Matrix Analysis**

Time Interval matrix is a research tool that fascinates the investigation of the reliability of decision by comparing the time interval of the indicator with the time content of reports.

Time Interval Matrix is kind of a 3D graph type with three true dimensions in data illustrated in 2D developed by the author. Figure 2.14 highlights how report time content (Z variable) changes according to the other dimensions, including Time period of reporting and size of workforce. The X-axis represents the time cycle that a company selected for periodic reporting and the Y-axis the number of full-time workers working in that organization during that report. The Time Interval Matrix is true X-Y-Z charts that Z has dependent on X and Y. In fact, exactly one Z value is set for each X, Y pair. Every point of the Time Interval Matrix represents the corresponding time content of the performance report that created by calculating the number of full-time workers during the specific time duration.

This matrix was used to analyze the reliability of the decision by using special performance indicators. By plotting the time interval of the performance indicators, the boundary of the performance report with reliable time content for decisions is highlighted beyond the time content of the performance report.
Injuries and fatalities related to work are occurring worldwide. Many rules and regulations of international and national regulatory bodies were made to prevent these; however, the injuries and fatalities are still occurring (Teo & Ling, 2006). HSE demand should be stimulated internally and externally for managers. External demand can be

Figure 2.14: Time Interval Matrix plotted by different Indicators time interval

2.6 HSE and Malaysian Business Community

Injuries and fatalities related to work are occurring worldwide. Many rules and regulations of international and national regulatory bodies were made to prevent these; however, the injuries and fatalities are still occurring (Teo & Ling, 2006). HSE demand should be stimulated internally and externally for managers. External demand can be
raised from government, media, regulatory, insurance, clients, and other external groups. This pressure could lead to an increase in internal organizational HSE demand by penetrating subsidiaries and departments. However, external demand is insufficient to increase managerial commitment to allocate more resources for better HSE. The internal organization demand would raise the organization awareness on HSE. Managerial priority to allocate resources for the approved plan is influenced by indicators that represent the managers’ outcome in response to both internal and external pressures. The indicators should be aligned with the outcome of the main business portfolio. Managers’ internal demand would increase if the official performance report highlighted how the business will be benefited by them. However, there is no guarantee for HSE resource allocation if the HSE plans are not linked to the direct performance of the managers.

This section examined HSE statistics and specification in the industry community in Malaysia, which is necessary for evaluating the impact of the research outcome in practice. The third complementary study of this research focused on the percentage of companies susceptible to reliable HSE decisions currently and in comparison with the time if the top HSE indicators are implemented. The first three sections in this chapter were allocated to the specification of industries, their workforces and HSE reporting in Malaysia. In the fourth section, different HSE performance indicators were calculated for the Malaysian community.

2.6.1 **Industries in Malaysia**

Malaysian enterprises are classified based on their size into four categories ranging from Micro enterprises to large enterprises. Small and Medium Enterprises are called SMEs. Based on the report of the Department Of Statistics Malaysia (DOSM), of Malaysian establishment and enterprises, 87% of total business establishments in the Malaysian industry in 2005 were SMEs. In 2011, SMEs increased to 645,136 of
662,939 total establishments in Malaysia (SMECorp, 2011), covering more than 97% of Malaysian companies. Most of these businesses (90%) are involved in the service sector, which includes wholesale or retail, as well as hotels and restaurants. The manufacturing sector, meanwhile, accounts for 6% of total SMEs or a total of 37,861 businesses, of which more than half fall under the three key subsectors, namely, textiles and apparels, metal products, and food and beverages (F&B). This is followed by the construction sector with 3%, and Agricultural sector 1% of SMEs (SMECorp, 2011).

Distribution of size of SMEs in Malaysia in 2011 indicated that 77% of this group were considered micro business (Tuyon, Bujang, & Jidwin, 2012) with less than five employees; 20% small in size with five to ten employees, and 3% as medium in size with 20 to 50 employees’ population (2011). Table 2.2 shows a short summary of data regarding the enterprise establishment in Malaysia (SMECorp, 2011).

Table 2.2: Distribution of Malaysian Corporations Sorted by Size, 2010

<table>
<thead>
<tr>
<th>Type of business</th>
<th>Range of Population (full-time workers)</th>
<th>Percentage</th>
<th>Total Number of Enterprises</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro Enterprises</td>
<td>&lt;5</td>
<td>74.69</td>
<td>495149</td>
</tr>
<tr>
<td>Small Enterprises</td>
<td>5_20</td>
<td>19.4</td>
<td>128610</td>
</tr>
<tr>
<td>Medium Enterprises</td>
<td>20_50</td>
<td>2.91</td>
<td>19292</td>
</tr>
<tr>
<td>Large Enterprises</td>
<td>&gt;=50</td>
<td>3</td>
<td>19888</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>100</strong></td>
<td><strong>662939</strong></td>
</tr>
</tbody>
</table>

According to the annual report of PERKESO, the official organization for social security in Malaysia, on 2010, the number of active employees in Malaysia was 5,519,000 who worked for 34,8000 active employers. This shows that, in 2010, the average number of employees working in each company was 15.8 per employer (importance of attention to SMEs) (Post, 2010).
The number of establishments per different industrial sectors and size are presented in chapter 4 (see Table 4.10). Approximately 70% of the Malaysian establishment is constituted by micro service companies.

### 2.6.2 Malaysian Workforces

According to the DOSM (2011), the Malaysian population in 2010 was 27,565,821. Of this population, some individuals are too young to work and others are over 65 and not working; some groups are unemployed and others are illegal foreign workers. Some groups of the workforce work at registered businesses and others work in government organizations or related parties. Overall, of 10.62 million Malaysian workforce members, 6.9 million work in registered businesses. This means that the ratio of people who worked per the number of people who were supported by workforces is 1 to 2.6: 6.9 million business workers directly affect 17.94 million Malaysian communities.

According to the annual report of PERKESO in 2010, the official organization for social security in Malaysia, the number of active employees in Malaysia was 5,519,000 employees, who were supported by social security.

Differentiating between what is reported by DOSH (6.9 million registered workers) and PERKESCO (5.5 million registered workers) may highlight the group of people who work without social security coverage or people who worked in more than one company.

---

**Table 2.3: Distribution of Malaysian enterprises in different sectors (Statistics, 2011)**

<table>
<thead>
<tr>
<th>% of Establishments</th>
<th>Agriculture</th>
<th>Mining</th>
<th>Manufacturing</th>
<th>Construction</th>
<th>Services</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Company</td>
<td>0.32</td>
<td>0.02</td>
<td>0.27</td>
<td>0.43</td>
<td>1.64</td>
<td>2.7</td>
</tr>
<tr>
<td>Micro Company</td>
<td>0.57</td>
<td>0.01</td>
<td>3.26</td>
<td>1.30</td>
<td>69.75</td>
<td>74.9</td>
</tr>
<tr>
<td>Small Company</td>
<td>0.29</td>
<td>0.02</td>
<td>2.10</td>
<td>1.01</td>
<td>16.00</td>
<td>19.4</td>
</tr>
<tr>
<td>Medium Company</td>
<td>0.15</td>
<td>0.02</td>
<td>0.35</td>
<td>0.60</td>
<td>1.89</td>
<td>3.0</td>
</tr>
<tr>
<td><strong>Total %</strong></td>
<td><strong>1.3</strong></td>
<td><strong>0.1</strong></td>
<td><strong>6.0</strong></td>
<td><strong>3.3</strong></td>
<td><strong>89.3</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The number of establishments per different industrial sectors and size are presented in chapter 4 (see Table 4.10). Approximately 70% of the Malaysian establishment is constituted by micro service companies.
The social impact of business activity can be traced by the number of workers rather than by the sole number of business firms. Therefore, the number of workers is calculated and prioritized for calculation of the social impact of business management. Table 2.4 highlighted the number of enterprises and their workers at different establishment based on the size of companies.

**Table 2.4: Principal statistics of Malaysian enterprises by sector and size (2010)**

<table>
<thead>
<tr>
<th>Enterprise groups</th>
<th>Number of establishments</th>
<th>Total number of workers</th>
<th>Indirect population support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>662,939</td>
<td>6,963,973</td>
<td>17,940,000</td>
</tr>
<tr>
<td>Large</td>
<td>17,803</td>
<td>3,294,714</td>
<td>8,487,564</td>
</tr>
<tr>
<td>SMEs</td>
<td>645,136</td>
<td>3,669,259</td>
<td>9,452,435</td>
</tr>
<tr>
<td>Micro</td>
<td>496,458</td>
<td>1,339,788</td>
<td>3,451,448</td>
</tr>
<tr>
<td>Small</td>
<td>128,787</td>
<td>1,470,955</td>
<td>3,789,350</td>
</tr>
<tr>
<td>Medium</td>
<td>19,891</td>
<td>858,516</td>
<td>2,211,636</td>
</tr>
</tbody>
</table>

**Figure 2.15: Distribution of SMEs vs. large enterprises in Malaysia, 2010**
Figure 2.15 highlights the difference between the distribution of firms and workers in SMEs and Large enterprises in Malaysia on 2010. As can be seen, while the number of SMEs represents 97% of total establishments in Malaysia, the number of workers in SMEs constitutes just 53% of workforce in Malaysia.

Figure 2.15 differentiates between the number of SMEs establishment and the number of supported workforce. While micro companies constitute more than 77% of SMEs, they include just 37% of the workforce in the micro category. In the same manner, the proportion of small and medium enterprises that constitute 20% and 3% of firms in terms of number would be changed to 40% and 23%, based on their respective population portions.

![Distribution of SMEs in Malaysia](image)

**Figure 2.16: Distribution of different category of SMEs in Malaysia, 2010**

A summary of the distribution of the Malaysian workforce is presented in Figure 2.17 demonstrates that 3,294,714 workers (47.3%) are directly managed under large enterprises, 858,516 workers are managed in medium enterprises, 1,470,955 workers in small enterprises, and 1,339,788 workers in micro companies (Statistics,
To determine the impact of decision making, it is necessary to estimate how many workers on average worked in each size of Malaysian company.

**Figure 2.17: Distribution of Malaysian workforce at different enterprises**

**Figure 2.18: Average workforce per industries in Malaysia, 2010**
Figure 2.18 highlights the average number of people working in each company in different industries and company sizes. According to Figure 2.18, the average number of workers in a micro company varied from 2.6 to 4.8 workers, which complies with the definition of micro company with a population of less than five workers. The small group of companies in service sector consists in companies with a population of between 5 and 19 workers. The number of workers in the manufacturing sectors is between 5 and 50 workers based on the definition of SME Corp. According the Figure 2.18, the average population in one small company in the service sector was 9.4 people and in non-service sectors ranged from 11.5 to 25.9 workers per company, in 2010.

Medium enterprises in service sectors cover companies with a population of 20 to 50 workers; however, this rate in manufacturing sectors is from 51 to 150 workers. In 2010, the average number of workers in one service sector was 31.1 workers and in non-service sectors ranged from 34.8 to 117.2 workers.

Large enterprises refer to service sector companies with a population of more than 50 full-time workers, while this rate in the non-service sectors consists in companies with a population of more than 150 full-time workers. Referring to Figure 2.18, the average population of a large company in the service sector was 105 people. This rate for non-service sectors fluctuated from 147.1 to 616 full-time workers. Table 2.5 displays a summary of the average workers in different sizes in comparison with their definition in Malaysia.
The distribution of the Malaysian workforce per different sectors is also presented in Table 4.14, Chapter 4.

Table 2.5: Summary of average workforce per enterprise in Malaysia, 2010

<table>
<thead>
<tr>
<th>Workforce per Enterprise</th>
<th>Micro Company</th>
<th>Small Company</th>
<th>Medium Company</th>
<th>Large Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Sector</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Definition</td>
<td>&lt;5</td>
<td>5-19</td>
<td>20-50</td>
<td>&gt;50</td>
</tr>
<tr>
<td>Rate at 2010</td>
<td>2.6</td>
<td>9.4</td>
<td>31.1</td>
<td>105</td>
</tr>
<tr>
<td>non-service Sector</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Definition</td>
<td>&lt;5</td>
<td>5-50</td>
<td>51-150</td>
<td>&gt;150</td>
</tr>
<tr>
<td>Min Rate</td>
<td>2.7</td>
<td>11.5</td>
<td>34.8</td>
<td>147.1</td>
</tr>
<tr>
<td>Max Rate</td>
<td>4.8</td>
<td>25.9</td>
<td>117.2</td>
<td>616</td>
</tr>
</tbody>
</table>

According to Table 4.14, large enterprises in the manufacturing sector covered approximately 16% of the total Malaysian workforces itself, which is similar to the large service companies. Micro service companies have covered the maximum percentage of Malaysian workers with 17.5%.
2.6.3 HSE Performance Report in Malaysia

2.6.3.1 HSE Performances in Malaysian SME

According to research statements, the HSE performance in a large company is better than in SMEs (Kheni, 2010); however, this is not true in all cases. In Malaysia, more than 97% of Malaysian industries are SMEs from which more than 70% are in service sectors that give their services to the large size company and public as well. SMEs in most developed and developing countries play a major role in their progress. For example, in Australia, the majority of construction industry firms are SMEs. They make up 97% of firms with a population of 20 and fewer employees, in which more than 85% consists in contractors with less than five employees (ABS, 1998).

The HSE foundation in SMEs is poor and unreliable. In terms of basic safety systems and standards, SMEs do not obey HSE rules as they were asked. The safety culture observation in Malaysian SMEs indicated the less attention to health and safety in Malaysian SMEs, let alone environmental matters. The evaluation of SMEs ranking in Malaysia, in terms of measuring the level of safety awareness, revealed that 37% of SMEs just achieved the awareness of grade D and of the others 73% took grade E out of five levels. This ranking ranged from Level A as the best to the lowest grade of E (Hatta, 2012). This means that no SMEs attained the average level of awareness of OSH in Malaysia in 2012.

SME challenges to safety management are not limited to Malaysia. Luning (2013) evaluated the food safety management at 50 Spanish enterprises. While all studied companies have benefitted from safety management systems, they found the operation is under a high level of risk. In addition, he found that the lowest performances of food safety management system belong to the smaller size enterprise (Rovira, 2013). In Australia, risk assessment is a basic legal requirement prior to handling a job; however, research by Mayhew (1997) found that SMEs undertake little on the OSH management
system. The outcome highlighted that enforcement improves little in safety performances in SMEs in Australia (Mayhew, 1997).

2.6.3.2 Safety and Health Performance Report in Malaysia

In Malaysia, strategies for occupational safety and health were developed by DOSH\(^{26}\) and controlled by their introduced indicators. The Malaysian industry in 2012 proposed to decrease the fatality rate by 20% of its rate in 2010 but instead of declining the fatality rate, it rose by nearly 20%. This increase happened while other indicators, including total recordable case of injury, dropped significantly. They achieved their targets in some indicators, but this achievement was not balanced.

From the reports issued by DOSH, the accident rate at the workplace in Malaysia declined from 9.5 (cases per 1000 workers) at 2002 to 6.1 cases at 2007 and then 4.9 at 2010 (DOSH, 2010). This rate dropped to 3.4 workers injury per 1000 workers in 2011 according to the official website (Council, 2011).

On the contrary, with a decline in the injury rate, the fatality rate (per 100,000 workers) increased from 9.5 deaths in 2002 to 12.4 work fatalities in 2007 (DOSH, 2010) and continued climbing to reach 13 deaths in 2010 (Post, 2010); it has since reached its highest rate of 15 deaths per 100 000 workers in 2011 (PERKESO, 2011).

Comparison of these two trends clearly highlighted the impact of enforcing safety regulations without creating the adapted culture. The author believes that increasing the disciplinary requirements for Malaysian companies raises their alarm in terms of reporting their incidents. This fear resulted in companies trying to show off without preparing proper tools and resources internally. In this situation, a company prefers to hide their incidents on their premises. This concealment will lead to a higher accident

\(^{26}\) Department of occupational safety and health
rate; however, they could not hide their deaths. Both remarks are clearly visible in Figure 2.19.

The other research in Malaysia did a short review of the most significant accidents in this country in construction industry (Abdullah, 2011). His study demonstrated the increasing rate of incidents in the construction industry from 2005 to 2008 and hoped that by implementing the MP15 plan in Malaysia, this trend would be decreased. The target set by the Malaysian government in 2015 according to the OSH-master plan is a 20% decrease in the rate of fatalities (approximately ten fatalities per 100,000 workers) and a 30% decline in work-related injury rate (approximately 3.4 per 1000 workers) (DOSH, 2010).

Figure 2.19: Comparision the trend of two result-base indicators in Malaysia

The other important point in their research was related to the statistic of foreign worker death among the described significant incidents. In March 2008, there were 2.2 million documented foreign workers, especially low skilled workers in construction and plantation sectors, which comprised 18% of total labor forces in Malaysia. From this,
36% are working in manufacturing, 16% in plantation and 15% in construction (Hasan, 2008). The Malaysian government is to reduce the amount of foreign workers to 1.5 million by 2015.

There are no statistics regarding the rate of fatalities in foreign workers in Malaysia as their fatalities were not recorded according to the Malaysian Occupational Safety and Health regulation (MALAYSIA, 2012). By analyzing the raw data reported by Abdullah in 2010 (Abdullah & Zain, 2011), regarding the most significant accidents in the construction industry in Malaysia, it can be seen that nearly 75% of total fatalities, between 2005 to 2007, were related to foreign workers, many of which were not recorded in the statistic.

2.6.4 Safety Performance Indicators in Malaysia

This section calculates some common lagging indicators that not directly reported by safety authorities in Malaysia. The reason for this calculation was to determine the most reliable indicators in Malaysia to compare with the top HSE KPI.

2.6.4.1 Total Recordable Case Rate

The total number of accidents reported by PERKESO in 2010 was 56,339, of 35,603 accidents were work-related. This number has a long distance, with 2,532 cases reported by DOSH in Malaysia as total fatalities and disabilities in that year. The difference between DOSH and SOSCO confirms that many accidents and occupational illnesses may not be reported to DOSH by companies; however, the workers went for using the insurances for treatments. The SOSCO statistic covers all accidents covering both industries and commuters as well as work illness (PERKESO, 2011). By removing the portion of commuters from the total recordable accidents in Malaysia, the numbers of accident cases were 38,657 for 2007 and 35,603 in 2010. The total recordable case

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rate (TRCR) is calculated by dividing the number of accidents (total accidents lead to fatalities, injuries, and illness) by the number of active workers in the year and then it should be normalized per 1000 full-time workers. TRCR for 2010 was 6.45, calculated using the Equation 1; Table 2.7 presents a summary of raw data extracted from SOSCO statistics.

**Equation 1: TRCF: Total Recordable Case Frequency Rate per 1000 workers**

\[
TRCF = \frac{\text{Number of working accidents with injury} \times 1000}{\text{Number of active employees}}
\]

**Table 2.7: The number of accident cases in Malaysian industries (PERKESO, 2011)**

<table>
<thead>
<tr>
<th>Year</th>
<th>2002</th>
<th>2007</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total industrial accident Case*</td>
<td>63423</td>
<td>38657</td>
<td>35603</td>
<td>35088</td>
</tr>
<tr>
<td>Registered Workers</td>
<td>5545943</td>
<td>5518823</td>
<td>5761626</td>
<td></td>
</tr>
<tr>
<td>TRC per 1000 workers</td>
<td>71.8</td>
<td>64.5</td>
<td>63.07</td>
<td></td>
</tr>
<tr>
<td>Industrial accident portion$^5$</td>
<td>68.6%</td>
<td>61.7%</td>
<td>58.5%</td>
<td></td>
</tr>
</tbody>
</table>

*TTotal Accident case includes all cases lead to medical, temporary disability, permanent disabilities and fatalities;

|$^5$: Refer to the rate of accidents recorded under the industries per total accidents recorded in Malaysia

2.6.4.2 **Total Recordable Injury Frequency, TRIF**

TRIF consists in the number of total injured or death because of work accidents or its occupational illnesses. To generate Total Recordable Injury Rate (TRIR/TRIF), the overall number of recorded people was divided to the number of active employees in the year, which presented in the Equation 2:

**Equation 2: TRIF: Total Recordable Injury Rate per 1000 active workers**

\[
TRIF = \frac{\text{Number of injured workers} (55277) \times 1000}{\text{Number of active employees} (5518823)} = 10.01
\]

Estimating the total number of injured workers in a country is difficult, as many of foreign injured workers are not supported by insurance. However, statistics from the safety and health authority could not provide a good estimation of total injured people. The only reliable references to estimate the total recorded injuries and death was
analyzing data published by social security statistics. By reviewing the SOSCO annual statistic, total recordable would be a combination of statistics of people who received injury compensation in one of the form of temporary or permanent disability, medical benefits, rehabilitation benefits and funeral benefits, excluding invalidity pensions, constant allowances, and survival pension. It should note that the physical and vocational or dialysis benefits were not considered; however, estimation could also have been faced with a data intruder. For example, one who was paid funeral benefits might be a receiver of the other treatment benefits before; on the contrary, one might directly opt for a funeral benefit. Moreover, statistics of SOSCO include the statistics of commuters from industry accidents. By considering this point on data mining of the annual report (PERKESO, 2011), the number of injured people (Equation 3) who received the compensation was:

Equation 3: Number of direct recipients from accidents

\[
D_{rc} = (D_t + (D_{p1} - D_{p0}) + (M_b + F_b)
\]

\[D_{rc} = \text{Number of direct recipients from accidents}\]
\[D_t = \text{Number of temporary disablement}\]
\[D_{p1} = \text{Permanent Disability of this year}\]
\[D_{p0} = \text{Permanent disability of Last year}\]
\[M_b = \text{Medical benefit}\]
\[F_b = \text{Funeral benefit from industries}\]

The number of funeral benefit was 1194 in 2010, the number of accident fatalities. Notice that survivor’s pension and dependent’s benefit, invalidity pension, and constant allowances were not considered in the above calculation, as they are not directly linked to work environment incidents.

\[D_{rc} = (48,804 + (29,914 - 26,660) + (2025 + 1194)) = 55,277\]

2.6.4.3 **Fatal Accident Rate (FAR)**

The rate of fatality is measured by dividing the sum of “number of people who died because of accident or injury or occupational illness” per “number of active employees
who worked at that year.” Different statistics presented for the number of deaths in Malaysia. According to DOSH, just 185 deaths occurred in 2010 but SOSCO reported 1194 deaths, including any type.

Reviewing details on SOSCO statistics showed that they paid monthly pensions for new family of 2777 members due to loss their worker in 2010. The number of funeral benefits paid by SOSCO was 9,816 people in 2010, which covered death either accidental or non-accidental. A study by SOSCO showed that 11.5% of people who left their job did so because of injury or fatal accident. If this rate was considered the adjusting factor on the funeral number, 9816, total accidental deaths would be 1129 people. This number (1129 death) is close to the total reported death in that year because of accidents (1194) by SOSCO. By multiple 61.7% as correction factor (industrial accident portion), the rate of death because of industrial accident would be 737 deaths. The fatality rate was normalized in 100,000 workers, calculated according to Equation 4:

Equation 4: Rate of fatalities per 100,000 active employees

\[
FAR = \frac{\text{Number of death} \times 10000000}{\text{Number of active employees}}
\]

\[
FAR = \frac{737 \times 10000000}{5518823} = 13.35
\]

2.6.4.4 Fatal Incident Rate (FIR)

Fatal incident rate is the other OSH indicator that shows the rate of incident cases lead to fatalities, which normalized per 100,000 full time workers; FIR calculated according to the Equation 5:
Equation 5: FIR: Rate of incident case leading to fatalities per 100000 workers

\[ FIR = \frac{\text{Number of accident with fatal injury}(736) \times 100.0}{\text{Number of active employees}(5,518,823)} = 13.33 \]

The raw data of fatal accident case in 2010 was 1191 (Mohammed, 2012); however, this number included commuter fatality cases. By considering the adjusting factor of 0.617, the number of fatality cases in business sector excluding commuters would be 736. This number supports the total working fatalities of 737 people. A summary of the above calculation on active Malaysian industry in 2010 is presented in Table 2.8.

**Table 2.8: The raw statistics of injuries and fatalities in Malaysia, 2010**

<table>
<thead>
<tr>
<th>Measurement factor</th>
<th>Quantity</th>
<th>Unite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incident cases lead to fatality</td>
<td>736</td>
<td>Case</td>
</tr>
<tr>
<td>Total fatalities</td>
<td>737</td>
<td>People</td>
</tr>
<tr>
<td>Total incident case lead to injuries</td>
<td>35,603</td>
<td>Case</td>
</tr>
<tr>
<td>Total Injuries</td>
<td>55,277</td>
<td>People</td>
</tr>
<tr>
<td>Total active employees</td>
<td>5,518,823</td>
<td>People</td>
</tr>
<tr>
<td>Total active employer</td>
<td>347,871</td>
<td>Company</td>
</tr>
</tbody>
</table>

Processing the above raw data leads to generate some common OSH performance indicators. Table 2.9 presents the adjusted OSH indicators in Malaysia in 2010 for the selected indicators. The mentioned data collected with lots of efforts just for estimating the benefit of this research in Malaysian communities; however, they need more investigation through its organization. It is reasonable that the number of fatalities and injuries were lower than the rate of the corresponding accident cases, as some of them may end with more than one injury or fatality. In fact the rate of injuries should be equal or higher than the number of accidents; similarly, this rate of death should be higher than the fatal accident. The calculation from two different methods leads to similar and
acceptable data. The author did not have access to more detailed information for further investigation.

By considering 52 working weeks per year, eight working hours per day, and five days a week, the total working hours would be 2,080 per person in a year. By subtracting two weeks work of paid vacation, there are 2,000 working hours per year.

**Table 2.9: The calculated safety indicators related to injuries and fatalities in Malaysia, 2010**

<table>
<thead>
<tr>
<th>Average Osh Performance measurement data</th>
<th>Quantity</th>
<th>Unite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatality Incident Rate/100,000 Workers</td>
<td>FIR</td>
<td>13.33</td>
</tr>
<tr>
<td>Fatality Rate/100,000 Workers</td>
<td>FAR</td>
<td>13.35</td>
</tr>
<tr>
<td>Total Recordable Case Rate/100,000 Workers</td>
<td>TRCR</td>
<td>645.1</td>
</tr>
<tr>
<td>Total Recordable Injury, Illness Frequency/100,000 workers</td>
<td>TRIF</td>
<td>1002</td>
</tr>
<tr>
<td>Injury Rate per 1000 workers (Malaysian Indicator)</td>
<td>MIR</td>
<td>4.9</td>
</tr>
</tbody>
</table>

According to Table 2.9, the ratio of injured persons per 10,000 workers per year is equivalent to 100.2 injuries and work illnesses. This means 100.2 injuries per 20,000,000 worked hours (time equivalent of 10,000 full-time workers per year). This statistic stressed the occurrence of one injury in Malaysia in 2010 was probable after working 200,000 working hours. The question is whether these working hours are suitable for monthly reporting, and in which situations.

Figure 2.20 shows a hierarchy of the normalized OSH performance data per 100,000 employees instead of 10,000 workers in Malaysia. According to Figure 2.20 within the 200,000,000 worked hours made by working of 100,000 full-time workers, 1002 workers were injured by 645 accidents. Moreover, in this amount of working hours, 13 cases of fatal accident lead to 13 deaths occurred just inside the business company, including its commuters and illness.
Table 2.10 presents the Time Interval of different indicators based on the amount of working hours, in which the occurrence of one case was probable.

Table 2.10: Minimum Time Interval (day) likely to have one case of the OSH performance indicators

<table>
<thead>
<tr>
<th>Average OSH Performance measurement data</th>
<th>Quantity</th>
<th>Unit</th>
<th>Time Interval (Equivalent Worked hours to get One $)</th>
<th>95% Confidence level range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal Incident Rate/100,000 Workers</td>
<td>FIR 13.3</td>
<td>Fatal Case/100,000 workers</td>
<td>1.66E+07</td>
<td>1.58E+07</td>
</tr>
<tr>
<td>Fatality Rate/100,000 Workers</td>
<td>FAR 13.3</td>
<td>Death/100,000 workers</td>
<td>2.95E+05</td>
<td>3.10E+05</td>
</tr>
<tr>
<td>Total Recordable Case Rate/100,000 Workers</td>
<td>TRCR 645</td>
<td>Incident Case/100,000 workers</td>
<td>3.10E+05</td>
<td>3.86E+05</td>
</tr>
<tr>
<td>Total Recordable Injury/Illness Rate/100,000 workers</td>
<td>TRIF 1002</td>
<td>Injury &amp; death /100,000 Workers</td>
<td>1.99E+05</td>
<td>1.89E+05</td>
</tr>
<tr>
<td>Injury Rate per 1,000 workers (Malaysian Indicator)</td>
<td>MIR 4.9</td>
<td>Injured worker/1000 workers</td>
<td>4.08E+05</td>
<td>3.88E+05</td>
</tr>
</tbody>
</table>

According to Table 2.10 fatality rate, FAR, was assumed to have occurred after 16 million working hours. TRIF has the least time interval and the highest probability of occurrence.
CHAPTER 3: METHODOLOGY

3.1 Research Objectives and Complementary Study

3.1.1 Research Target

Establishing the HSE performance communication network to improve HSE commitment in managers was approached by answering different research questions. Static and dynamic concepts were considered for this network investigation. Within static approach, the research concentrated on determining the proper indicators and proper time for each management layer.

1- Empirical investigation of the top 5 HSE indicators at different management levels by answering:

What are the 5 top HSE indicators for each management level?

By time justification on the collected time in static approach, the second objective of this research was:

2- Developing BT for different management levels by answering:

What is BT for each management level to collect performance data?

Moreover, to find out the key indicators at dynamic concept, the third objective was:

3- Which HSE performance indicators could be the top business HSE KPI?

By answering these three questions, the researcher could set the proper time and indicators on the HSE performance network for both static and dynamic approaches. However, it is also necessary to highlight some communication rules of this network for internal interactions. Two complementary questions set for these purposes were:

4- Shall the time period for data gathering and data reporting be the same at each managerial level?

5- Does any change in the organizational point of view lead to significant changes at the requested time of reporting?
The last complementary study was to study the social impact of the discovered HSE KPI.

6- How significant is the research outcome in Malaysia? What percentage of the seasonal safety performance report would be reliable if they employed the research outcome?

3.1.2 Research Assumptions

Exploratory research has its limitations and assumptions. As there is no past accepted research methodology, the author studied the research elements. Limitations are those elements that are not under the control of the exploratory researcher; however, the research assumptions provided a steady condition that helped move the research forward.

The first assumption is that the suitable HSE KPI should be free from type of operation or activity and could be employed by different management levels. To control this limitation, managers from a different point of view and from different responsibilities were invited.

The second assumption is that all managers shared their experiences without considering what was implemented in their organization.

The third assumption is that this research did not intend to develop any new HSE indicators. So, finding the most effective HSE performance indicators and HSE KPI just carried out on the subject of indicators that employed by companies or organization in somewhere. To eliminate these barriers, the researcher studied the subject of indicators, which is understandable by managers and one indicator was used as a sample to help managers’ understanding. In fact, managers were invited to select the subject of measurement rather than being confused by a variety of technical indicators.

Minimum Time Interval in this research was one working day of data gathering. In practice, managers could not inform the number of working days for reporting; they
simply selected how often they needed this report. To eliminate this error in quantifying the time period in working days, this research has concentrated on the industries that work seven days per week, such as shore or offshore industries or their subsidiaries.

3.2 Methodology Details

A communication network needs right indicators at the right time for right manager. Figure 3.1 demonstrates two streams for data analysis at two concepts. In the static approach (a), the top 5 HSE indicators were investigated from a list of indicators for different management layers.

In the dynamic approach (b), the selection of top HSE KPIs was based on the organizational point of view. In the following sections, the method for measuring each objective is explained. Two controlling barriers were considered for each to reduce data inaccuracy.
3.2.0 **HSE Indicator Subject (Primary Data)**

The input data on the first layer were gathered by reviewing many HSE reports of companies; however, some of them were introduced by HSE organizations or authorities. Primary data was sufficiently reliable, but the author considered them as primary data only. A pool of HSE indicators, measures, and KPIs (participated companies or international authorities, such as ILO, OSHA, ISO, OGP, UNDP, et cetera.) was gathered and used for further evaluation.

Primarily 64 and finally 45 of the indicators were categorized as selected subjects for interview by managers. These subjects were grouped into eight categories.

1- “Meetings group” is a wide range of meetings from the daily meeting till yearly or from a small gathering of workers to management reviewing.

2- “Management system” that covers different indicators that is always being asked by management systems or highlighting its progress.

3- “Training and skills” is related to HSE indicators employed for training and competency improvement.

4- “Hazard monitoring” represents the raw data for hazards identifications or its control.

5- “Participation and culture” represents the measurement subject of the culture and awareness level of people in the workplace.

6- “Incident” related to the incidents with different consequences in work environment in a single form or accumulative.

7- “Indicating” include multi dimension layer of indicators used for benchmarking or comparison.

8- “Socio-Environment” included the most common social and environmental indicators subject.
**Controlling factor (0.1):** As they adopted from published performance reports, primary control for their usage is conducted by the user at the origin.

**Controlling factor (0.2):** To test whether the subjects were understandable, they evaluated the discussion by managers and experts during trial analysis. In fact, the primary pilot test leads to a change in the number of primary HSE performance subjects from 64 to 45.

### 3.2.1 Top 5 HSE Performance Indicators (PI)

HSE Performance Indicators (PI) were HSE indicators selected by participants in interviews from the HSE indicators primary list. This stage is a fundamental step of research as it transforms qualitative data (indicator subject or indicator name) to quantitative data based on the desire score given by participants.

**Analysis Method:** This objective was achieved by passing the following five stages:

1. Interview by managers to get the perspective of managers in practice.
2. Increase discrimination between indicators by limiting managers’ choices to their top 5 selections out of 45.
3. Evaluating the importance of each indicator between the top 5 indicators by rank them from first to fifth.
4. Quantifying the rank to the score number, described separately.
5. Selection of Top 5 HSE indicators for each management organizational level.

It should be noted that each indicator might be assigned a different score at each management perspective. Six managerial levels participated in this research and were classified into two organizational points of view. In the macro point of view, three management levels were classified, including:

A) Macro perspective managers:

Top Management Ranks, called Managers with Macro Perspective:

- Board members
• Chief Executive Officer or Managing Director, as an administrator in charge of total management of a large enterprise.

• Senior Management (SM), known as a senior executive authority, as the second top authority in large enterprises, who supervise a group of managers or responsibilities in line with business strategy.

B) Micro perspective managers:

Middle Management layers, called Micro Perspective Manager, including:

• Line Manager, Executive Manager, and Operational Manager; from an executive perspective, they are managers who supervise special field directly. This group is not included foreman.

• HSE representative/executive/manager\(^{28}\) who coordinates the HSE of the company as the main in charge person.

• Contractors Managers or SMEs’ top Manager; contractors at large sized companies were not studied in this group. Managers in this group are independent of the other organizational management levels; however, their activities are directly influenced by connection to their clients’ requests.

Research Tool: The primary research tool for selecting top 5 indicators was a questionnaire with a list of 64 indicators. After the pilot test, this tool replaced with a new designed indicators pocket card that embedded with an answer sheet (Appendix A). In this tool, indicators with similar group were given a specific colored toolbar to help managers easily discern them. Interviews were recorded and, at the end, a box of 45 HSE indicators was given to participants to appreciate their participation.

\(^{28}\) HSE Manager in some companies refers to the senior managers; however in this research it refers to the executive HSE Manager at the working level.
Controlling factor (1.1): Score calculation may involve mistakes. To control for this fact, the sum of total score at each management layer should be 15, as each manager should prioritize its top 5 selections between 1 and 5.

Controlling factor (1.2): The other error in finding a top 5 is type I error because of errors in the managers’ mind in developing countries. To control for this error, the validity of answers must be controlled by a controlling factor. In this research, time was used as a controlling factor.

3.2.2 HSE KPIs Selection

Analysis Method: The ranks given to indicators during the interview were used for score calculation. At this stage the score calculated based on the point of view. KPIs should be of interest to the macro perspective managers.

Besides of scoring, Top HSE KPI should be the strategic driver as defined by Patrick (2005). Strategic driver is a continuous measure, which is extended from operational drivers at executive layers to the upper managers at the organization top chart.

Data Analyzing: Any performance indicator with the highest score may not be the most eligible one to nominate as the top HSE KPI. It should be the most important strategic driver for macro point of view. Patrick highlighted 80% of the senior manager’s task passed through strategic drivers and just 20% use by operational drivers. Therefore, to find the candidate with the top HSE KPIs, the indicator’s score was calculated based on point of view given by a macro perspective manager. The top HSE KPI was then controlled to be the strategic driver.

Controlling factor 2.1: Total score at macro perspective controlled to prevent score calculation errors.

Controlling factor 2.2: Rather than calculating the top HSE KPI based on Macro Perspective Managers, the score was recalculated by considering both Macro and Micro
Perspectives. This margin (50–50) was much higher than the ratio mentioned by Patrick (20–80).

3.2.3 **Blue Time Interval**

Desired time for data collection was another element asked of all participants. BT is the optimized time cycle for HSE data gathering between managerial levels in an organizational communication network. Time needed was gathered in interviews on static approaches based on time scales. The time period was then translated to time length (working days) to calculate its average. The time needed at static concept justified between layers to develop BT. BT has two sides as shown in Figure 3.2. From one side, a suitable time cycle for data gathering by managers is shown; on the other hand, its timeline characteristics made it reliable to integrate with other business indicators or performances.

*Analysis Method:* Desired time for data gathering (Input) and data reporting (Output) were collected for each management level. Output Performance Reporting addresses the desire of managers to publicize their performance while Input Performance Reporting pointed to the time cycles a manager enforced subsidiaries to send their report at that cycle. While BT was the adjusted time cycle for HSE data gathering that has a common multiple between different organizational levels under ± 0.05 deviations.

*Data Analyzing:* Participants shared their needs for reporting at different time scales (daily to weekly, monthly, quaternary, biannually, and annually). Given time cycles may generate different time content depending on a business work schedule (five working days or seven working days per week). These cycles should be normalized.
before converting to a daily base. To eliminate any error in this normalization, all invited and selected companies were having seven working day schedule.

*Research Tool:* In the interview with managers, two important questions were asked:

1. Based on your past working experience at the current management level, what is the most effective time frequency for HSE performance data gathering from your subordinate at the normal business condition?

2. Based on your past working experience at the current management level, what is the most practicable time period for reporting, if you desire to send the HSE performance report to the upper organizational level, at normal business condition?

*Controlling factor 3.1:* To control participants’ suggestion on time cycle, data gathered on two different points of view. 1) Look from down to up was compared with the 2) look from top to down. The bottom-up view from managers presents their desired time to publish their performance reports, while the look from up was the time during which subsidiaries were being forced to send their progress reports.

*Controlling factor 3.2:* BT for different management layers should tune up in one timeline to set an integer fraction of reporting cycles. This adjustment should be within the accepted differential.

3.2.4 **Data Flow at Management Level**

Complementary study conducted on the direction and specification of this communication by extra analysis on gathered data. The questions were

5. Shall the time period for data gathering and data reporting be the same at a managerial level?

Some managers’ are directly willing to forward the received performance reports from subsidiaries. To examine whether this approach is true or false, the desired time for HSE performance data collection and its reporting were compared statistically.
Different ties of input time and output time were aligned to study the following hypothesis using SPSS, highlighted in Figure 3.3.

\[ H0: \text{There are no meaningful differences on Time for Input and Output performance reports for a manager.} \]

\[ H1: \text{There are meaningful differences on Time for performance data gathering and performance data reporting to a manager.} \]

The rejection of the null hypothesis in narration means that

\[ \text{Time period for HSE performance data gathering and performance data reporting should be different at a management level.} \]

![Figure 3.3: Manager point of view hypothesis](image)

Controlling factor 5.1: To minimize statistical error, a sufficient sample population was invited. Around 108 cases of ties were set for this test.

Controlling factor 5.2: The statistical exams conducted on 95% confidence intervals.

3.2.5 **Data Flow at Point of View**

6- Does any change in the organizational point of view lead to a significant change at the requested time for HSE performance data gathering?
The requested Input Time on two general point of view, macro and micro perspective, were examined by a statistical test (Figure 3.3). The following hypotheses were considered to examine the mentioned question:

\[ H_0: \text{The distribution means of Time is the same across both Micro and Macro management perspectives.} \]

\[ H_1: \text{The distribution means of Time is significantly different across both Micro and Macro management perspectives.} \]

The rejection of the null hypothesis in narration means that

\[ \text{The Time for collecting HSE performance reports should be different by changing the managers’ point of view.} \]

Controlling factor 6.1: Having enough of a sample to minimize the statistical errors.

Controlling factor 6.2: The statistical exams conducted at a 95% confidence interval.

3.2.6 **Research Impact Analysis**

*Analysis Method:* To study the social impact of the founded KPIs, the current probable safety indicators in Malaysia and the new founded HSE KPI were examined through the Time Interval Matrix. The descriptive analysis highlighted the percentage of Malaysian companies and their workers that benefit the founded KPI.

*Data Analyzing:* To measure the reliability of performance report by Time Interval Matrix, it is essential to understand two factors: 1) Time interval of selected Indicators and 2) Have an estimation of Time content of performance report at companies. Both were adopted from Chapter 2.

While a monthly report would be much more effective for decision makers, this research tested different periods of reporting ranged by accepting seasonal performance report. However, the reliability of the seasonal HSE performance report used to analyze the impact assessment.
Controlling factor 7.1: Descriptive analysis alone might encounter a decision with bias error while comparing the changes in the same population would eliminate this error.

Controlling factor 7.2: The average population of each group and using the official data from the past record would increase the validity of estimation. However, 95% confidence interval considered for providing the primary estimation on each case before comparison.

3.3 Research Participants

3.3.1 Sample Population

Before starting the research, it was necessary to clarify the sample size of the population that needed to attend in the survey. By knowing the sample size, it would be easy to determine how many people we needed to interview with. Moreover, the precision level that exists in our sample could be determined. Detection of sample size depends on the determination of three important factors including the population size, the confidence interval and the confidence level.

The population size that supported this research was around 4,000,000. Confidence interval is the minus-or-plus fluctuation rate beyond the average that if the question asked from population, the same answers would have picked. We considered plus-minus 10% for the outcome of this research. Finally, as all managers are free to do its selections so the chance of selection or rejection of the indicator is 50% (the worst case). Primary sample calculation highlighted 96 participants for the main research. The researcher invited more participants and the interview was completed by 11 people for the trial stage and by 108 managers for the main research. Based on this number, the primary statistical limitation improved as follows:

- The management population raised to 4,000,000 managers
- Sample population increased from 96 to 108 interviews according to calculation
- The confidence level of \((1-\alpha)\) 95\% and the chance of answering (50\%) not changed
- The new confidence interval is recalculated and improved from ± 10\% to ± 9.43\%

### 3.3.2 Invited Companies

The selective sampling method will be used at the first stage to invite the different type of industries; however, their response was not under the researcher’s control. Inclusion criteria for participation invitation was having a seven working day schedule and the benefit of an Integrated Management System for at least one successful external audit experience. Type of business was not important if they met the primary criteria. The rank of managers was also a key factor in sample classification; manager attendance at the interview was arbitrary. It depends on having free time during the time that the researcher was in their company’s premises.

An official invitation letter sent to more than 62 companies in more than 12 different industrial groups in Iran and Malaysia as the Islamic developing country. Enterprises were asked to permit the researcher to access the field data, HSE document reviewing and interviews with the managers at different organizational levels. Interviews with each manager lasted one hour, which was enough for HSE data gathering discussion. The list of the distributed invitations is presented in Table 3.1.

**Table 3.1: Industrial distribution of the invited companies at the first stage**

<table>
<thead>
<tr>
<th>Industry Group</th>
<th>Number of sent invitations</th>
<th>Received responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy industry,</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Chemical and petrochemicals,</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Logistics and Transportation,</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Oil and Gas Constructions,</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Oil and Gas Process Operation,</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Professional or training Industry,</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Palm Industry,</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Port Industry,</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>
3.3.3 **Participants Specification**

More than 125 managers and supervisors shared their experiences in this study during the interview that lasted for two years. Few of the responses were removed due to missing data which is not a serious problem as it was higher than requested samples (Graham, 2000). The average respondent population at each organizational level varied from a minimum of 9 participants to a maximum of 27. Specification details of participants are presented in chapter 4. Anonymity and confidentiality were guaranteed for all participants, although they were interested to share their ideas in this research. All participants were experienced managers and supervisors at different organizational levels and all were employed in international companies established in developing countries. They were asked to neglect the severe working circumstances that influence their routine decision. Some participants were unwilling to report their HSE data due to the fact that they may be prosecuted. To remove this limiting belief, participants were asked to answer the entire questions in the frame of freedom with no penalties.

### 3.4 Indicator Score Calculation

During the interview, each participant was asked to give a priority rank to the indicator subjects which ranged from 1 as the best (most preferred) to 5 as the least. As 45 indicators were presented to each participant, only five indicators got the score 1 to 5, while the indicators achieved a score of zero in the calculation of the case. The score given by all the participants of a level was calculated through Equation 6, which was developed by the author.

\[
\text{Equation 6: Score calculation based on the ranks given to each indicator}
\]

\[
\text{Equation 6: Score calculation based on the ranks given to each indicator}
\]

\[
\bar{P}_{jg} = \frac{1}{\sum_{i=1}^{n} \sum_{l=1}^{k} \omega_{il} a_{i}}
\]

which means that
According to this formula, the score of each HSE indicator fluctuates between zero and five. Zero means that none of the participants selected it at least once and five is given if all participants in that group selected the indicator as the first priority. According to Equation 6, the quantitative score of any HSE performance indicator varied between two extreme limits (0–5).

A summary of calculation for two points of view ($K > 1$) and each managerial level ($k = 1$) is presented in Table 3.2. It shows an example of how PI1 score calculated based on the frequency of priority that given by participants.

### Table 3.2: PI Scoring sample for separated/integrated organizational level

<table>
<thead>
<tr>
<th>PI 1</th>
<th>Counting per different organizational levels</th>
<th>To total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Board</td>
<td>CEO</td>
</tr>
<tr>
<td>Priority</td>
<td>Weight</td>
<td>N</td>
</tr>
<tr>
<td>5 4 3 2 1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

$PI_{jg} = \frac{w_1(a_{g1}+a_{g2}+\cdots a_{gk}) + w_2(a_{g1}+a_{g2}+\cdots a_{gk}) + \cdots + w_n(a_{g1}+a_{g2}+\cdots a_{gk})}{N_1+N_2+\cdots+N_k}$

$PI_{jg}$: is the weighted mean given to the PIj from point of view g

$w_1$: is the weighting factor for KPI priority

j: is the numerical ID represents HSE Indicator

g: is the point of view that the HSE Indicator was assigned to

$\alpha_g$: is the frequency of HSE Indicator selection within the same rank within group g

N: is the total number of participants at the organizational level of g; (e.g., 28 for SM)

k: is the number of organizational levels that the score was aligned to

According to this formula, the score of each HSE indicator fluctuates between zero and five. Zero means that none of the participants selected it at least once and five is given if all participants in that group selected the indicator as the first priority. According to Equation 6, the quantitative score of any HSE performance indicator varied between two extreme limits (0–5).

A summary of calculation for two points of view ($K > 1$) and each managerial level ($k = 1$) is presented in Table 3.2. It shows an example of how PI1 score calculated based on the frequency of priority that given by participants.
The first row in Table 3.2 presents the level of management and the second row highlights the amount of people that stand in that group. Next rows were allocated to the number of selections at each priority that was given by each management level. The last row presents the average score that is given by participant in terms of the organizational level in both forms of single managerial view or within the group (organizational point of view). For example, the score for PI 1 for senior manager (SM) level with 28 sample population, highlighted that just two people of 28 selected this indicator as their top priority; one selected PI1 as their second choice and three selected it as their fifth. The other 22 participants did not select the PI1 in their top 5 selections. The score of PI1 in point of view of a Senior Manager would be calculated as the following:

\[
P_{PI1_{SM}} = \frac{5(2) + 4(1) + 3(0) + \ldots 1(3)}{28} = \frac{10 + 4 + 3}{28} = 0.6
\]

\[
P_{PI1_{Macro}} = \frac{5(2 + 0 + 0) + 4(1 + 0 + 0) + 3(0 + 0 + 0) + \ldots 1(3 + 1 + 0)}{28 + 19 + 11} = \frac{10 + 4 + 4}{58} = 0.31
\]

\[
P_{PI1_{mm}} = \frac{5(0) + 4(0) + 3(2) + 2(0) + 1(4)}{26} = \frac{10}{26} = 0.38
\]

\[
P_{PI1_{Micro}} = \frac{5(0 + 0 + 5) + 4(0 + 0 + 4) + 3(2 + 1 + 0) + 2(0 + 2 + 1) + 1(4 + 4 + 0)}{26 + 23 + 15}
\]

\[
P_{PI1_{total}} = \frac{5(0 + 2 + 0 + 0 + 5) + 4(0 + 1 + 0 + 0 + 4) + 3(0 + 0 + 2 + 1 + 0) + 2(2 + 0 + 0 + 0 + 2 + 1) + 1(0 + 1 + 3 + 4 + 4 + 0)}{11 + 19 + 28 + 26 + 23 + 15}
\]

\[
P_{PI1_{Total}} = \frac{5(7) + 4(5) + 3(3) + 2(3) + 1(12)}{122} = \frac{35 + 20 + 9 + 6 + 12}{122} = \frac{82}{122} = 0.67
\]

\[
\frac{25 + 16 + 9 + 6 + 8}{64} = 1.0
\]

3.5 Statistical Test

The two different hypotheses require different research methodologies. The first one needs to compare the mean time differences of one variable in one population for two concepts (Input and output performance report). The second one is going to compare one variable for two independent groups (micro and macro).
3.5.1 **Comparing Two Related Continuous Variables**

Wilcoxon Matched-Pair Signed-Rank test was used to evaluate the time differences for the two report scopes. Time Interval data was interpreted from categorical format into numeric data per day. As all participants have seven working days, this transition was done with no challenges. Moreover, two statistical groups were dependent groups. Moreover, the Wilcoxon signed rank (WSR) selected for this comparison in which the number of samples in both communities should be the same.

According to the methodology of WSR, for each record, the difference on means $d_{ij} = x_{i1} - x_{i2}$ was computed by SPSS software. Nonzero absolute differences were sorted into an ascending order where then the ranks were assigned. The average and sum of the rank which corresponds to positive and negative differences were then calculated (Donham, 1985; Siegel, 1956).

3.5.2 **Comparing Two Independent Variables**

The second statistical hypothesis of this study examined differences in time between macro and micro groups. As these groups were independent observations, the Mann–Whitney test (MWT) was selected instead of Wilcoxon test. However, because of population differences in the groups, the adjusted form of MWT, called the Mann–Whitney U test (MWUT), was used for examination. Using MWUT, the point of view of 52 macro observations in relation with 56 micro observations were tested through Dinneen’s formula through the SPSS software.

3.6 **Methodology Power Control**

Measuring the properties of a methodology or diagnostic model generally defined based on a matrix of 2 x 2, in which one side represents the test result and the other side represents the true value that might be distributed in the samples. In this research, the methodology was designed to choose the top 5 HSE performance indicators within six managerial levels. So, the methodology distinguished 30 top HSE PI overall. However,
the True HSE PI might be less than this rate as some of them might be rejected by the time (controlling factor). The definition of Sensitivity, Specificity, Positive predictive value (PPV), Negative predictive value (NPV), and prevalence could be extracted from the matrix, which was described separately. This research sought positive answers rather than concentrating on the negative side (Not interested indicators). Therefore, the sensitivity, specificity, negative predictive value, and prevalence tests are not meaningful. The only meaningful test is the Positive Predictive Value (PPV).

Methodology precision or PPV is defined based on the probability of distinguishing a true case to all diagnostic cases. As this research aims to determine just five of 45 indicators, so, the probability of a true PI were diagnosed out of all selected PI by managers. In fact, PPV provide a proper estimation on how true was the managers’
selection, which has the highest importance. The PPV will calculate through \( \frac{A}{A + B} \) as illustrated in Figure 3.4.

3.7 Shortlisted HSE Measures and Their Classifications

By reviewing the annual reports presented by companies or pioneer organizations in developed or developing countries, and considering HSE indicators and measurements highlighted in literature review, more than 100 HSE indicators were identified while many of them were derived from the same roots. Many of these indicators were originally introduced as HSE KPIs or performance indicators by their users. In the pilot test, 64 subjects of the most important indicators went on trial within 11 interviews.

The reasons for failure at the pilot test were: 1- similarity between some of indicators subjects, 2-numerous choices and many details on the questionnaire and limiting space, and 3- different perceptions of indicator meaning by managers. Therefore, to eliminate these problems: 1- the indicators substituted by the indicator subjects and putting just one indicator as a sample for each subject. 2- Instead of having 64 indicators, only 45 indicator subjects were utilized for the interview. 3- the questionnaire was also redesigned and made into pocket cards in which each card was allocated to one indicator. The cards present a fixed description to all interviewees to help them find better understanding. Besides, the color-coding classified them into eight different categories. Each indicator was given an ID which ranged from 1 to 45, as presented in Figure 3.5.
A summary of indicators on each group is presented at the end of this section.

3.7.1 **Group 1: HSE Meeting Group**

The HSE Meeting Group represents measures that address some sort of meeting outlines to manage HSE meetings. This group does not cover training; however, much decision making and planning can be done by the meetings listed in this group. The following indicators were considered in the group:

3.7.1.1 **Subject No.1-Toolbox Meeting**

Toolbox is a common name for meetings in many industries and refers to a brief meeting at the start of the day (15 minutes) that give everyone clarity about what needs to be done safely, what are the safety precautions in devices, operations, work sequences and arrangements of routine or emergency situations. The meeting has to be held by operation supervisors or team leaders in the scene and is attended by all corresponding workers. Workers have to report related HSE problems to their
supervisors; however, these problems are always about the unsafe conditions in job practices. These meetings have many HSE advantages for a company to control all last changes in execution and reminding safety precautions and practices in place. On the other hand, many toolbox meetings in routine operation may become boring and are just conducted as a formal function if they are not held properly. The aim of introducing this indicator is to evaluate how much importance it has for managers’ performance.

3.7.1.2 Subject No.2- Safety Committee Meeting

This meeting is almost requested by Occupational Health & Safety regulation body in the country and not by the environmental authority. However, the level of its support by top managers differs between companies. The advantage of this meeting is the external support of regulatory authorities, which makes the decisions of this group more restricted. On the other hand, as the decisions of the meeting will be enforced by regulators, it may be considered an internal spy in the companies. However, it could be set up more positively for win-win management. The outcome of this meeting was questioned in the interviews.

3.7.1.3 Subject No.3- Incident Investigation Meeting

This subject address the meeting outcomes held by the company to identify root causes and casual factors of incidents or near misses. The investigation could be very useful if they are handled with the right procedures.

3.7.1.4 Subject No.4- HSE Planning Meeting

Technical meetings and risk assessment could be another subject for performance monitoring. Different risk assessment meetings are held in companies such as Job Safety Analysis (JSA), Post JSA, HAZOP, and HAZID, Pre-start up, or Pre-commissioning or Risk Assessment meetings that have been arranged.
3.7.1.5 **Subject No.5- Management Review Meeting**

Number of Meetings or Number of Closed Items is the other sort of meeting headed by the top manager. It would be a completely formal meeting under the Chairmanship of the Facilities Manager and will be held at regular intervals to discuss the function of the HSE management system and review the past performances and targets. It brings higher commitments to different business functions to meet the set goals. However, this meeting couldn’t be held frequently and often held once a year. Therefore, it could not be helpful for improving HSE commitment in short term.

3.7.2 **Group 2: Management System Group**

The main attribute subjects in this group are concentrated on the management system. Management systems elements generally are leadership and commitment, planning, implementation, document control, resource control, review and monitoring of performance, continuous improvement, and consultation (Cooke, 2011). Almost all managers in organizations believe that having the management systems are important for their reputation externally, but they are unsure how effective the management systems are for their work operation. They just follow the market tendency and they add it as one project to their business project without attending to the models attached. Having a management system does not necessarily guarantee high HSE performance if proper measures are not involved or employed.

3.7.2.1 **Subject No.6- Work Procedures**

Number of written HSE procedures generated or revised is the subject of performances within a management system. Companies have some master procedures and documents that help them to revise and extract the executional procedures on that basis.
3.7.2.2 **Subject No.7- Frequency of HSE Inspections**

Rate of HSE inspection could be another subject of measurement demonstrating how the HSE is organized in a company. In some companies, the HSE systems are being inspected by officers in place, while in others, HSE officers are advisors and the safe job is implemented by the people. Sometimes the high level of hazard risk needs company to assign more HSE officers and higher rate of inspections. In one of the registered companies this rate was one HSE officer per 30 workers. Sometimes this subject was reported based on HSE inspected hours per 1000 worked hours. This factor demonstrated how HSE resources were provided for operation.

3.7.2.3 **Subject No.8- Number of Inspections by Project Administrative Team**

HSE inspections by managers could demonstrate the HSE commitment at companies. Managers have conducted site inspections so the number of inspections by PAT could improve the HSE atmosphere in the company. Workplace tour by middle and senior managers in the work area once per month was observed in one of the registered companies.

3.7.2.4 **Subject No.9- Management System Score**

It addresses the scoring system to monitor the system implementation by system administrators. The different score system implemented to control what level of system is implemented and how it was maintained. The output would be a raw score or the percentage of system implementation by dividing the sum of all actual criterion scores (AC) per sum of all maximum criterion scores (MC) x 100 (Weiss & Wagner, 2000).

3.7.2.5 **Subject No.10- Non- Conformity Records (NCR)**

The number of minors/majors NCR is calculated based on the number of observed lapse (Minor) and total number of absences or total breakdown of a required process (Major). NCR will be applied to system attribution not in place. If the procedures are not followed, then NCRs have remained on documents.
GROUP 3: HSE Training and Competency Group

HSE knowledge improvement and HSE skill enhancement are the other group to classify HSE performance subjects.

Subject No.11- Training within HSE Matrix

The percentage of training within the company could be another subject to monitor the HSE performance. By counting the man hours of training for specific HSE subjects this measure could be measured. This matrix will organize essential safe skills for workers, such as safe and best practices during the main duty of employees such as rigging, lifting, welding, cutting, etc.

Subject No.12- HSE Induction

Number of HSE induction is another activity of HSE performance for new comers. The Gate Pass is issued only to those who successfully attended inductions. Many important HSE rules were briefly explained, but not in depth.

Subject No.13- HSE Drill

Different types of drills are carried out in companies in a specific time period in routine or unscheduled plans, such as fire, medical services, rescue, environmental spillage, and natural disasters. This exercise is intended to train and recall people in practice for their duties and escape procedures. However, more benefits are for emergency members.

Group 4: Hazard Monitoring Group

This group contains indicators with subjects of hazard identification and monitoring. This hazard is not just related to safety aspects, but also covers all substandard practices in environmental and health.

Subject No.14- Unsafe Act

Number of recorded unsafe acts is the other subject of HSE performances.
It includes any mistakes, violations, lapses and slaps on safety practices and accepted procedure and norms that may cause incidents. It may be the sole cause of incidents or one of several causes. An unsafe act is a violation from. Safe act and unsafe act are complementary.

3.7.4.2 **Subject No.15- Unsafe Condition**

It could be a deviation from safe conditions within mechanical, physical, chemical, or environmental condition, situation, or state of affairs may be accomplished with incident. The aim of introducing this measure is to evaluate how much importance it has for managers for decision making. Safe condition and unsafe condition are complementary.

3.7.4.3 **Subject No.16- The Number of Issued Permit**

Permits are always issued when the necessary safety precautions have been taken for specific activities or high-risk operations being on plan. Different types of permits might be designed for different operations and some of them ask for more technical clarification and complementary certificates by third parties. It could be a subject of HSE performances.

3.7.5 **Group 5: Contractors and Participation Group**

Other subjective HSE indicators were allocated to HSE culture and participation climate. Four different measures were assigned to this category, which is described below.

3.7.5.1 **Subject No.17- Stakeholders’ Participation**

Number of direct reports from stakeholders on HSE was a symbol of their participation. Workers are the main part of stakeholders. Direct reports from employees on HSE matters are the outcome of many different elements, such as HSE commitment, organization culture resilience, change management, and awarding systems.
3.7.5.2 Subject No.18- HSE Award

Some companies were interested to report the number of HSE initiatives. Different means were taken by the company to motivate the staff and supervisors. The total amount of money or the number of people who received awards was considered as one of the HSE indicators, which represents how companies promote HSE activities.

3.7.5.3 Subject No.19- HSE Coverage in Contract

Contracts and bids with HSE layer is the other subject of HSE performances. It might be the percentage of HSE budget in contract to the number of suspended contract due to poor HSE performances. Tender should include HSE budget estimation and contractual provision to suspend operations due to HSE violations.

3.7.5.4 Subject No.20- HSE Organizational Culture

HSE cultural level is the other subject of HSE performance measurement, ranging from pathological to generative levels by Hudson (2007); however, different methods and questionnaires were suggested by other experts for this purpose.

3.7.6 Group 6: Incident Group

This group contains indicator subjects related to the number of incidents and accidents. It covers a wide range of incidents occurrences (recordable and non-recordable).

3.7.6.1 Subject No.21- Near Miss

The number of near hit events are the counter of the number of events were had potential to cause injury or damage or loss, but not lead to damages to people or asset beyond the accepted level by the companies. In fact, near miss is an incident in which no property was damaged and no injury sustained, but in which a slight shift in time or position, damage and/or injury occurred. This measure is important in many companies, but the coverage of its record was challengeable. The statistic of a near miss is not evaluated by regulation bodies or national organizations and they considered near
misses as non-recordable incidents. The aim of introducing this measure is to evaluate how much importance it has for managers for decision making.

3.7.6.2 **Subject No.22- First Aid Case (FAC)**

Number of minor injury not recorded/number of cases of minor work injury or illness such as cleaning minor cuts etc. FAC does not need medical devices or treatment and not considered in Total Recordable Injuries (TRC). However, it can provide an estimation of number of small injuries in work environment with potential for more severe incidents. Items such as bandages, sterile-strips, cold or hot therapy, vaccination, using non-prescription medicines, flushing, cleaning and wound covering, neck collars, removing foreign bodies from eyes, and using eye patches are classified in this measure.

3.7.6.3 **Subject No.23- Non-Injury Accident/Incidents**

It covered total number of events or chain of events caused damage to assets, the environment or third parties but not lead to injury. For example, any unplanned events result in damage or loss of property, plant materials, environment and/or a loss of business opportunity such as fire or explosion, environmental incidents, quality incidents, and vehicle incident.

3.7.6.4 **Subject No.24- Total Recordable Injury/Incident Case (TRIC)**

This measure is used to count the total number of incident case with different severity includes 1- Fatalities, 2- Lost Work Day Case, 3- Restricted Work Day Cases, and 4- Medical Treatment Cases. As this indicator covers a wide range of incidents, it has more records than the other recordable incident measures. However, it considered the same weight for different injuries.

3.7.6.5 **Subject No.25- Medical Treatment Case (MTC)**

A medical treatment case is an injury that needs emergency medical services but is not severe enough to for workers to be off work or doing restricted jobs. It covers the number of injured or sick persons requiring treatment (more than first aid), such as
wound-closing and prescription medication and removal of foreign material that is embedded in the eye. However, the severity of reported incidents within this measure is not severe enough to have a lost work days or restricted tasks (Cloughley & Thomas, 1998).

3.7.6.6 **Subject No.26- Restricted Workday Case (RWDC)**

The number of cases of incidents or injuries in which employees cannot fulfill their normal work the day following an incident, but is able to undertake a temporary job. Moreover, any work-related injury other than a fatality or lost workday case, which results in a person being unfit for full performance. The case does not have days away from work, but has days of restriction.

3.7.6.7 **Subject No.27- Lost Work Day Case (LWDC)**

Number of cases of accidents leads to injury, in which an employee was absent from scheduled work because of work illness or injury. It does not include the day of the incident and does not cover fatal cases.

3.7.6.8 **Subject No.28- Lost Time Injury (LTI)**

It addresses the work related injury or illness which prevents a person from doing any work the day after the accident. It includes different injuries with different lost time. It may range from one to indeterminate days off work because of severe fatality or death. It would not consider MTC or RWDC.

3.7.6.9 **Subject No.29- Fatality**

The fatality is a range of work incidents with severe injuries and death. In this research it refers to the work incidents cause the people death or disability. It also covers death or disability as a result of occupational illness. This measure can be calculated by counting the number of incidents leads to fatality or by counting the number of fatalities directly.
3.7.6.10 Subject No.30- Days Away or Restricted or Transferred Duty, (DART)

DART counts the number of LWDC (#26) and RWDC (#27). Cases that involve lost
time, or days of restricted work activity or job transfer, or both were considered in this
indicator; however, this did not include fatality cases.

3.7.7 Group 7: HSE Indicator Group

This group includes subjects that present the normalized rate of accidents. Time or
the number of workers is the main subject of the normalization based on the
organization needs. For example, in the UK, the normalization factor for some
indicators is 100,000 full-time workers, which is equivalent to 200 million working
hours. This constant for OGP members is in half rate because of limited working hours
in business Companies. This difference can be seen between companies. For example,
BP provides some of its reports based on 200,000 man-hours, while Shell acts the same
as OGP and uses 1,000,000 man hours.

It should be noted that the number of incident cases is different with the number of
injured people by the case of accident. Incident and accident also has different meaning
based on the safety policy of companies. In this research, these two have the same
meaning because of having the same subject.

3.7.7.1 Subject No.31- Days Away or Restricted or Transferred Duty Rate,
(DART Rate)

This subject refers to the normalized DART cases; for example, per 200,000 worked
hours.

3.7.7.2 Subject No.32- Lost Time Injury Frequency (LTIF)

LTIF address the normalized rate of fatalities resulted by accident lead to the injuries
with the lost working days or death. It might be normalized per 1,000,000 work hours.
The constant may be changed from company to company. This indicator just shows the
frequency of injuries with LWDC and Fatality Cases but does not provide any data
regarding the weight of the incidents. Some companies substitute the number of injuries by the number of incident cases and called it LTC Frequency Rate.

3.7.7.3 **Subject No.33-Lost Work Day Severity Rate**

This subject points to how severe was the LTI cases on average.

3.7.7.4 **Subject No.34- Total Recordable Injury Rate/Frequency (TRIR/TRIF)**

TRIF points to the normalized rate of recordable injuries. This measure is a common HSE performance indicator in different companies that generally used for comparison the safety performance with the other same business on benchmarking. It might be normalized per 100 full-time workers per year.

3.7.7.5 **Subject No.35- Fatal Accident Rate (FAR)**

FAR points to the normalized rate of death and not incident led to death. This subject may be termed Recordable Fatality Rate by some companies. Because of rare frequency, the normalizing factor is almost about 100 million man-hours worked.

3.7.7.6 **Subject No.36- Fatal Incident Rate (FIR)**

FIR referred to the normalized rate of fatal accident case. The normalizing factor is different between countries and in general used 100 million man-hours worked. In UK it normalized per 100,000 workers while the OGP reports use 100,000,000 man-hours.

This subject shows the frequency of incident cases that resulted in one death, or a complete disability and does not provide information about the number of fatalities.

3.7.7.7 **Subject No.37- Process Safety Event/Incident Rate (PSER/PSIR)**

This indicator is a new indicator introduced by ANSI 2008 for process operation on company premises. This measure is calculated by counting different type of near misses, environmental incidents and some important process failures that might lead to the accident or process incidents. The number of incidents of unplanned or uncontrolled incident by Lose of Primary Containment (LOPC) of any type of material including toxic/non-toxic and flammable/non-flammable materials in direct contact with operation
will be considered and normalized per one million worked hours. This indicator is interesting as it integrated different incidents with different aspects by one measure. It includes lost time injury, fire with direct damage above $25000 on assets or the chemical release and environmental impact beyond the acceptable threshold limit.

The limitation is that it just considered the incidents have direct impact on process and not the rest of business. In fact, a process must have directly impacted by damage. The term “process” broadly includes the equipment and technology needed for chemical, petrochemical and refining production, including reactors, tanks, piping, boilers, cooling towers, refrigeration systems, etc. Incident with no direct chemical or process involvement is excluded; for example, an office building fire, even if the office building is on a plant site, is not reportable (CCPS, 2011).

3.7.7.8 Subject No.38- Process Safety Incident Severity Rate (PSISR)

This subject refers to the severity of the PSIR. It can report directly in raw format or it can be normalized through the ratio of Total severity scores per 200,000 work hours. The constant may change in companies and can be reported separately. To calculate this indicator, incidents are classified in four levels and 1 point is assigned for each Level 4 incident attribute, 3 points for each Level 3 attribute, 9 points for each Level 2 attributes, and 27 points for each Level 1 attributes. Theoretically, a PSI could be assigned a minimum of 1 point (i.e., the incident meets the attributes of a Level 4 incident in only one category) or a maximum of 108 points (i.e., the incident meets the attributes of a Level 1 incident in each of the four categories. The advantage of this indicator is that small incidents have a different weighting factor with large incidents.

3.7.7.9 Subject No.39- Total Hazard Potential (THP)

THP is another HSE performance subject that address the overall hazard potential by HazPoC (Hazard Potential Cases). It includes all hazardous conditions (identified risk with assessment/incidents) and will be assigned to the tasks, projects, fields and
company. The amount of THP can easily be changed by adding or terminating activities. This indicator just presents how the cloud of hazard potential of an activity being integrated and how it changed over the time. Having high THP does not have negative meaning, but also it demonstrates how high risk job is under safe operation. This measurement for generation needs IT structures. Calibration of this indicator will be done by direct comparison with result base indicators. This indicator has been developed and implemented since 2009 within few Iranian companies.

3.7.7.10 **Subject No.40- Mitigated Hazard Potential (MHP)**

Total migrated hazard potential is the other subject of HSE performances. MHP reported based on HazPoC depends on the preventive actions, corrective and correction actions. This indicator presented how much of the identified THP is under control. The ratio of MHP to the minimum requested MHP (according to the ALARP risk level) demonstrated the HSE performance of managers.

3.7.8 **Group 8: Socio-environmental Group**

Five different socio-environmental measurement subjects are short-listed in this group.

3.7.8.1 **Subject No.41- Energy Intensity Rate**

The ratio of energy consumption to gross domestic product, or other industry output was one of the environmental subjects that defined as the energy consumption. The ratio can be reported as per gross of domestic product, or other industry output such as sales, freight ton-miles and GDP as an economic output.

3.7.8.2 **Subject No.42- Waste Discharge**

Different wastewater indicators might be employed by companies, of which some of them pointed to the special specification of waste such as wastewater load, wastewater solid flux and other technical indicators.
3.7.8.3 **Subject No.43- Recycled, Reused and Recovered Material (3R)**

It refers to the solid waste measures such as tons of Hazardous/Non-Hazardous waste recycled, reused, or recovered from waste stream. It highlighted the amount of waste generated by the company. The amount of recycling waste per generated waste might be normalized by unite of production.

3.7.8.4 **Subject No.44- Social Contribution Fund**

Financial and nonfinancial social contributions would be the other HSE performance subject; for example, $ million on social responsibilities or a number of local people trained or employed.

3.7.8.5 **Subject No.45- Air Pollution**

It addressed the air pollution measures as part of the HSE performances. Total quantity of GHGs released to the atmosphere is a representative all other air pollution measures in this research.

A summary of all mentioned indicators and its related group is presented in Table 3.3 and Table 3.4.
<table>
<thead>
<tr>
<th>HSE Indicators Grouping, Case ID</th>
<th>HSE Indicator/Measure Descriptions</th>
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<tr>
<td>Meetings Group Subjects 1 1</td>
<td>Number of Toolbox Meeting</td>
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<td>2 2  Number of Safety Committee Meeting</td>
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<td>Management System Subjects 1 6</td>
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CHAPTER 4: RESULTS AND ANALYSIS

4.1 Introduction

This chapter comprises the results gathered from interviews with the managers to explore three objectives and three complementary questions. It also contains the score given to each indicator by six management layers and from two organizational points of view. The top selected HSE performance subject by each management levels in line with time control was explained. The analysis was then conducted to develop BT at each management layers statistical test highlighted some facts regarding the data flow at HSE communication networks in business companies.

Result and discussion for objectives of this research carried out in seven sections including the data collected, raw data analysis, and their discussion as discussed below:

1- Participant Specifications,

2- Performance Indicator Scoring,

3- Blue time for Management Layers,

4- Top 5 HSE performance Indicators

5- Top HSE KPI,

6- Complementary Analysis,

7- Power of methodology for estimation the true PI,
4.1.1 Participants Specifications

Approximately 125 managers were invited to be interviewed, in which data from 11 persons were used for primary trial test. From the 111 managers who were chosen for the interview, 108 managers completed their interviews at their work place. The companies were located around Malaysia from Port Klang to Johor to Sarawak regions and also in the south of Iran and within the offshore platforms on the Persian Gulf. During the interview, a box of HSE Card including 45 indicators was distributed to participants to facilitate their selections and help them to discern differences among subjects.

Distribution of participants in terms of their managerial level was displayed in Table 4.1. The ratio of answers in Iranian and Malaysian managers was 44% to 56%. Approximately, 63% of participants were managers from oil and gas industries that mainly operated in port or offshore fields such as the Iranian Offshore Engineering Company (IOEC), Bintulu Port, and Tidewater Middle East Company. Approximately, 15% of the experience of participants was in the professional and consultant companies, such as managers in Malaysian MSOSH, Lloyds, Certification bodies, and offshore engineering. The only food industry in this research was the Malaysian Coca-Cola branches, which worked seven days a week. Kuala Lumpur International Airport, KLIA, and Malaysian Sime Dobby were two other big participants in this research. The only drilling company was an Iranian Offshore drilling company that worked in the Persian Gulf.
In Appendix B, the ID of top 5 HSE performance indicators that were selected by managers out of 45 cards are displayed and sorted based on management level.

4.2 Performance Indicator Score

During the interview, participants gave a priority rank from 1 for the most desired, to 5 as the fifth desired subject in their top 5 selection. Thus, out of the 45 presented subjects, only 5 subjects achieved ranks and 40 subjects were null. The scores calculated then it being compared with the highest score at that management level. The priority rank for each indicator was calculated in which the maximum rank was 45, and the least rank was 1. Similar score was given the same rank.

4.2.1 Group 1: HSE Meeting Group

According to Figure 4.1, Toolbox meeting TBM (PI1) is most desired by Middle Managers (JM/MM) and SMEs Managers; while Board members had no interest on the TBM subject. Middle managers choose this indicator with a significant priority of 45
out of 45. In the same manner SMEs managers also showed interest by giving the significant rank of 43 out of 45. Based on the organizational POV, “Tool box meeting” ranked as the second priority by micro perspective with a score of 44. In contrast, the interest of Macro perspective manager was not high enough (26).

PI2, safety committee meeting with the lowest rank is not in the top 5 selection by managers at different management levels. This reluctance emphasized that managers have no interest in this indicator.

PI3, incident investigation meeting was selected by majority of the managers. PI3 was at the top preferred list of managers with micro perspectives, but was not included in their top 5 selections. The interest for PI3 increased with higher management levels.

HSE planning, PI4, is also of interested to two management groups: middle managers and HSE managers by a rank score of 42 and 44, respectively. However, PI4 was not considered a top priority by micro and macro perspectives.

The last indicator of group 1 is PI5. It is interesting to mention that “Management review meeting,” PI5, did not fit into the top 5 selected indicators by micro perspective managers. By contrast, it gets the significant priority with a score of 41 at macro perspective managers. PI 5 was solely the interest of chief executive officers and the board in contrast to the middle and SME managers who did not show interest in this indicator.
Figure 4.1: Management preference on HSE indicators for Group 1

Figure 4.1 illustrates that the interest of managers to the “Management review meeting” decreases by climbing down the organizational ladder. The interest of the HSE planning meeting increased in the lower management levels, in which more attention was given by HSE managers. The interest in the incident investigation meeting increases with higher management ranks, but it stops at the CEO level. Safety committee meeting is not an interest among all management levels. Toolbox meetings are of interest to middle managers and SMEs that faced executive tasks in the front line of operation.

The two preferred HSE indicators by senior managers from Group 1 are PI3 and PI4. PI3, Incident investigation meetings and PI4, HSE planning meeting are two indicators
that senior managers put within their top 5 selections, which received significance ranks of 42 and 44, respectively.

4.2.2 Group 2: Management System Group

According to Figure 4.2, Procedures, PI6, is of more interest to micro perspective than macro perspective managers, obtaining the rank of 42 from the micro perspective. This score emphasizes how strong the pressure of management systems is on contractors to present their working procedures. Surprisingly, none of the managers with macro perspectives selected it in the list of their top 5. The frequency of inspection or the number of HSE patrolling, PI7, is another subject for HSE indicators that highly interested by HSE manager. It achieved a significant rank of 41 out of 45 by contractors’ management or SMEs’ managers.

Figure 4.2: Management preference on HSE indicators for Group 2

According to Figure 4.2, Procedures, PI6, is of more interest to micro perspective than macro perspective managers, obtaining the rank of 42 from the micro perspective. This score emphasizes how strong the pressure of management systems is on contractors to present their working procedures. Surprisingly, none of the managers with macro perspectives selected it in the list of their top 5. The frequency of inspection or the number of HSE patrolling, PI7, is another subject for HSE indicators that highly interested by HSE manager. It achieved a significant rank of 41 out of 45 by contractors’ management or SMEs’ managers.
The other three indicators of this group did not appear in the top 5 selections of all organizational levels including PI 8, inspections by the project management team, PI9, management system audit score, and PI10, Number of NCRs.

According to Figure 4.2, the disregarded indicator by both micro and macro perspective managers is the HSE inspection by the project management, PI8. This means that none of the HSE managers and the board members chose this indicator in their five selections.

The audit subject, PI9 was not selected by any of the different levels on the list of top 5 selections. The average score given to PI9 by both management perspectives was 20 for Micro and 27 for Macro perspectives. Moreover, none of the middle managers and board members preferred this indicator.

The number of non-conformance records is the last indicator in this group, in which macro perspective managers are interested at a higher rate than micro perspective managers. However, none of the management groups selected PI10 in their list of top 5 indicators (Table 4.12).

The second group of HSE indicators was a common subject of the management system. Five different indicators were presented in this group, in most of which different management levels were not interested.

PI7, frequency of HSE inspection is the sole indicator of this group that is desired by HSE manager. The highest rank is 45 of 45. It emphasizes that HSE inspection is important for HSE managers.

4.2.3 Group 3: HSE Training and Competency Group

Group 3 comprises three subjects of measurement in terms of training and competency including drills and training. Training is a common activity in many companies that is reported in many internal performance reports by HSE departments. Three subjective elements were evaluated in this group. Empirical investigation
highlighted that none of these indicators being focused in the top 5 indicators of different management levels. Moreover, none of them obtained a high score at organizational POV.

The statistics on the HSE training matrix, PI 11, was of interest to micro perspective managers, especially middle managers and HSE managers, as shown in Figure 4.3. However, most of the managers with macro perspective are not interested in the HSE training of workers. The number of HSE inductions, PI12, is the other indicator that highlighted in Figure 4.3. None of management groups marked this indicator on the top 5.

![Management preference on HSE indicators with Training Subjects](image)

**Figure 4.3: Management preference on HSE indicators for Group 3**
PI11, HSE matrix training, is highly preferred by HSE and middle managers. However, the CEO and senior managers are reluctant to both HSE training and induction. HSE drill is the only indicator in this group that was supported by different management levels unless the board members. The SMEs prefer to conduct HSE induction in their premises as they could not plan a complete training matrix on their operations for the workers in short term.

4.2.1 Group 4: Hazard Monitoring Group

Group 4 consists of three indicators that being used for hazard monitoring and its control. A summary of ranks given to these indicators is presented in Figure 4.4. Two indicators out of three were selected on top 5 priority by Middle managers and HSE managers which caused that PI 14 and PI 15 was selected within the top 5 at micro perspective group. PI 15, unsafe conditions, has higher rank than Indicator PI14, Unsafe Act by scores of 44 to 42, respectively.

According to Figure 4.4, unsafe acts, PI 14, is of high interest to managers with Micro perspectives while the managers with Macro perspectives had lower interest in unsafe acts. In the macro perspective, PI15 was not selected by the CEO and board members; however, it reached the high score by the senior managers. PI 15, unsafe condition, is the only indicator that in favor of senior managers in his top 5 HSE indicator list. Comparison of PI 14 and PI15 at the senior management level highlighted that senior managers are more interested in unsafe conditions than in unsafe acts.

PI 16, HSE permit, was not focused by managers at different organizational levels. It was also not selected by HSE managers. It emphasizes that in HSE operation, HSE permit is part of the job that must be done; however, attention to its record cannot be a proper means of performance measurement.
The scores and ranks given to four different HSE performance indicators listed in Group 5 is illustrated in Figure 4.5. Employee’s participation (PI17) is one of the cultural subjects for measurement. The majority of managers at different organizational level are interested in this indicator; however, the score given by HSE managers and board members were lower than the other managers. PI17 with a rank of 43 was highly preferred by the CEO level. Although micro managers did not select this indicator within their top 5, SMEs gave a relatively high rank to this indicator, with a rank of 40.

HSE award subject, PI18, received attention by most management levels; moreover, it reached the third priority level by the Board level. Generally, this indicator is of more interest to macro POV managers than to managers with a micro POV.

Figure 4.4: Management preference on HSE indicators for Group 4

### 4.2.1 Group 5: Contractors and Participation Group

The scores and ranks given to four different HSE performance indicators listed in Group 5 is illustrated in Figure 4.5. Employee’s participation (PI17) is one of the cultural subjects for measurement. The majority of managers at different organizational level are interested in this indicator; however, the score given by HSE managers and board members were lower than the other managers. PI17 with a rank of 43 was highly preferred by the CEO level. Although micro managers did not select this indicator within their top 5, SMEs gave a relatively high rank to this indicator, with a rank of 40.

HSE award subject, PI18, received attention by most management levels; moreover, it reached the third priority level by the Board level. Generally, this indicator is of more interest to macro POV managers than to managers with a micro POV.
Desire to the PI19, contract with HSE coverage, at Macro perspective managers is significantly higher than managers with Micro perspectives; however, none of the managements ranked it within their top 5 selection. This indicator was not selected by micro perspective managers.

The last subject in group 5 was HSE culture level, PI20. This indicator is highly respected by Macro perspective managers. Board Members designated it as one of the top 5 indicators with a rank of 43. The preference trend in lower organizational levels was decreased. In fact, none of the micro perspective managers preferred this indicator.

![Figure 4.5: Management preference on HSE indicators for Group 5](image)

Figure 4.5: Management preference on HSE indicators for Group 5

According to Figure 4.5, HSE awards and the organizational culture are of interest to board members. The majority of indicators at Group 5 are not of interest to HSE managers. Attention to employee participation through both SMEs and CEO groups emphasized that top managers of organizations with different sizes are keen to improve worker participation. In addition, HSE culture and tenders HSE coverage are
disregarded by all micro perspective managers, including middle managers and HSE managers and SMEs. This means that PI19 and PI20 are impractical as HSE performance measures on the small organizational scale.

4.2.1 Group 6: Incident Group

Approximately ten different subjects with direct incident measures are listed in Group 6 as illustrated in Figure 4.6. Near misses, PI 21, were selected by Micro perspective Managers as their top selection, which addressed the high desire to this indicator within all related managerial levels. In fact, this indicator is designated as the top 5 selections by SME managers, middle managers, and HSE managers. However, by climbing the organizational rank, the preference to this indicator is declined of which board member put this indicator on their lowest rank.

The subject of incident classified under first aid cases considered by different managers as the non-important HSE performance indicator by overall rank and not marked by them.

The number of non-injury incident obtained the high interest by CEO; however, this was not selected as the top 5 indicators at both Micro and Macro perspective. No concern by HSE managers is shown to this indicator that refer two different concepts between HSE manager and CEO interest.

Total recordable case of injuries was the other indicator that not interested by the Board members and HSE managers. By contrast, all management levels were interested in PI 24 with rank of 33 and above, as shown on Figure 4.6. Total Recordable case of incident/injury obtained the rank of 43 at the Macro perspective. Overall, this indicator is selected as the third highest rank of 45 indicators.

The Medical treatment case (PI25) as the fifth indicator in this group, was not of interest to the majority of managerial levels. In fact, the score given to it has big differential among the top 5 subjects.
The Restricted Work Day Case (PI 26) in similar to PI25 was not of interest to the majority of managerial levels. In fact, this indicator was the lowest interest by all excluding SMEs manager.

The Lost Work Day case, PI27, as the other subject of incident was not of interest to the majority of management levels. However, interest in this indicator is higher than in PI25 and PI26.

The Lost Time Incident case, PI28, as a common HSE indicator was not of interested by a majority of managerial levels, especially HSE managers, SMEs, board members, and CEOs. Attention to this indicator in Macro perspectives is higher than in Micro perspective; however, it still is low.

Fatality is another incident subject, which was not selected by CEO, senior managers, and line managers. Just board members have common attention to it.

DART indicator is the other subject in incident group. Managers with both Micro/Macro perspectives have similar attention to PI30, with the average priority. Moreover, HSE managers chose DART indicators on their last choices.

Group 6 contained a wide range of different HSE indicators within the raw incident subjects. Out of ten HSE indicators that presented to the managers, just three of them could enter within the list of top 5 HSE performance indicators.

PI 23, non-injury incident, is preferred by CEOs, with a score of 41 out of 45. PI 24, total recordable case (Incident/injury), is the top interest of senior managers by rank of 45. The next rank is given by middle managers to PI 24 by a score of 40. In overall perspective and in Macro perspective view, PI 24, TRC, was the introduced indicator of rank of 43 within the top 5 selections.

According to Figure 4.6, Micro perspective managers are highly interested in the Near miss indicator, while managers with the Macro point of view highly preferred Total Recordable cases.
Figure 4.6: Management preference on HSE indicators for Group 6

4.2.1 Group 7: HSE Indicator Group

Figure 4.7 illustrates a summary of ranks and score of ten HE subjects. Most of the measured subjects in this group were reported as HSE indicators in international and national organizations such as OGP, Shell, and DOSH, etc.

The DART rate (PI31), was not interested in majority of organizational levels. However, managers with micro POV paid more attention to it than macro groups. This
trend was opposite to the LTI rate (PI32), which had higher preferences by Macro than Micro POV.

Severity of LTI (PI33) was not selected by any managers at different organizational levels. PI 34, total recordable case rate, the same as PI 24 (TRC), followed the same pattern of interest between Macro and Micro perspective managers. While the preference of the TRC rate in Macro group is higher than Micro group, PI34 was not included in any of top 5 indicators. Comparison between the number of TRC and Rate of TRC pointed to the higher score at the number of TRC than its rate.

Fatal Accident Rate (PI35) designated by Board member and SME managers with common score. However, PI35 has not high enough to include within the top 5 indicators similarly.

Fatal incident rate (PI36) was not preferred by different management levels. The interest in both FAR and FIR in Macro perspectives is higher than in Micro perspectives.

Process safety event (PI37) did not get into the top 5 by different organizational level as it mainly focused on process incidents. Process safety event severity rate (PI38) is not of interest to different managerial levels. Severity indicators of PSE and severity rate of LTI, were both of lower interest than the main indicators.

The ninth indicator in this group is THP. Macro perspective managers designated Total hazard Potential Indicator (PI39) as the first selection in their top 5 list. Moreover, from an overall perspective, PI 39 obtained the highest score of the 45 indicators. Regardless, the average rank given by middle managers (22), the other managerial levels gave the rank of 37 and above to PI 39.

The last indicator in this group was MHP (PI40). All managerial levels gave the average rank and above on PI40 as shown in Figure 4.7. Mitigated Hazard potential obtained the second rank in both total perspective and Macro perspective with rank of
44. The rank given to MHP with SMEs and CEOs Managers make it inside the top 5 indicators.

PI31 to PI36 is the normalized rate of the incidents that occurred with different consequences. Out of these six indicators, none of them include on the top 5 lists of managers. In a same manner, PI 37 and PI 38 were not selected by managers. PI 39, Total Hazard potential, and PI 40, Mitigated Hazard Potential, are two HSE indicators significantly respected by different management levels. However, they did not enter the top 5 selections by middle managers, board members and HSE managers.

PI 39 obtained the highest rank in total score, as well as Macro perspective managers and specially CEO with rank of 45. The SME managers as well as senior managers give rank of 42 to PI 39. On the other hand, board members and HSE managers selected this indicator with a score of 38 of 45.

In SMEs, PI 40 ranked with higher rank than PI 39. In fact, SMEs selected MHP as the highest preferred indicator rather than the others. However, from an overall perspective, PI 40 is selected as the second most important HSE performance indicators after THP. Except the middle managers that rank 19 to PI 40, board members, senior managers, and HSE managers select this indicator respectively with grade of 40, 40 and 35; PI40 has not been selected within the top 5 selections in the Micro Group.
The last group of indicators in this research consisted of measures with the subject of social-environmental aspects. Energy consumption rate as PI41 in this group is of interest to most management levels excluding SME managers. According to Figure 4.8, Macro perspective managers are more interested in Energy consumption than are Micro perspective managers. Board members are the only group of managers that designated this indicator within the top five selections. Consciously, SMEs failed to select PI41 in their top five options.

Figure 4.7: Management preference on HSE indicators for Group 7

4.2.2 Group 8: Socio-environmental Group

The last group of indicators in this research consisted in measures with the subject of social-environmental aspects.

Energy consumption rate as PI41 in this group is of interest to most management levels excluding SME managers. According to Figure 4.8, Macro perspective managers are more interested in Energy consumption than are Micro perspective managers. Board members are the only group of managers that designated this indicator within the top five selections. Consciously, SMEs failed to select PI41 in their top five options.
The majority of managers were reluctant to select wastewater subject (PI 42) under their top 5 selections. However, just 9 people out of 108 votes to this indicator at their fifth priority of the top 5.

Waste management subject (PI43) could not receive the interest of the managers at different levels. The majority of managers was also reluctant to select waste recycling (PI43) or related indicators within their top 5 selections.

The interest in social contribution subjects (PI 44) in Macro perspective managers is higher than in managers with Micro perspectives. The 5 top selection of board members was social contribution with an average score of 2.2. In contrast to the board, middle managers and HSE managers were reluctant to include this in their top 5 selections.

Finally, none of the participants’ chose the air pollution subject in their top 5. This means that it is not the priority of different management levels.

Of the five subjects listed in Group 8, only energy consumption could be achieved the overall score of 32 out of 45. This means that environmental and social performance indicators are not important in view of companies in comparison with other subjects. PI 45, Air pollution, PI 43, waste management, and PI 42, wastewater have the lower interest rank in this group, with a rank of 1, 5, and 11 of 45, respectively. PI 41, energy consumption rate was designated by board members with a rank of 42 of 45. It is interesting to note that social contribution is a top selection of the board members, while this indicator was not included in the top 5 HSE indicators of the Macro group. The other remarkable point is that, based on the given priority, HSE managers desire energy consumption to be higher than the other environmental subjects, such as air, solid waste, or wastewater indicators.
According to Figure 4.8, by climbing the organization management ranks, interest in energy consumption indicators is increased.

4.3 **Blue Time Interval Data**

Each management level has the desire to collect the HSE performances at the desired time interval. However, at the dynamic concept of communication, these desires must be balanced. The adjusted time interval for data gathering between managers is called Blue Time (BT). In order to develop BT, it is necessary to investigate the Time Interval required by each management level. During the interview in fields, managers stated their desired Time Interval for both HSE data gathering and reporting.
4.3.1 **Time Interval for Input HSE Periodic Report**

Table 4.2 presents descriptive data from interviews with 108 managers in the concept of an input HSE periodic report. This data demonstrates a desired time interval by managers in static concept.

**Table 4.2: Desired Time Interval for Input performance report by managers**

<table>
<thead>
<tr>
<th>(Day)</th>
<th>Board Member</th>
<th>Chief Executive Officer</th>
<th>Senior Manager</th>
<th>Middle Manager</th>
<th>SMEs Manager</th>
<th>HSE Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>196</td>
<td>95</td>
<td>41</td>
<td>10</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>123</td>
<td>92</td>
<td>68</td>
<td>12</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Variance</td>
<td>15092</td>
<td>8455</td>
<td>4666</td>
<td>137</td>
<td>34</td>
<td>6</td>
</tr>
<tr>
<td>Maximum</td>
<td>360</td>
<td>360</td>
<td>360</td>
<td>30</td>
<td>30</td>
<td>7</td>
</tr>
<tr>
<td>Minimum</td>
<td>30</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

According to Table 4.2, board members prefer to receive the HSE performance reports at a period of 196 days on average. So, sending the HSE report in less time than this is not desired by the board, on average. CEOs desire to collect a periodic safety report on the period of 95 days, which is approximately seasonally. This time period in SMEs manager is five working days, which is equal to one week. The sharp declining trend from board members to CEO and to contractors may highlight the intensified responsibility of managers at the execution level, rather than at indirect organizational levels. The desired TI for HSE managers, middle managers (line managers), and senior managers are two, ten, and 41 working days, respectively. The distribution of Time Interval at different organizational levels is drawn on the logarithmic scale to highlight the significant changes by changing between organizational levels. According to Figure 4.9, the mean of the time interval is raised by raising the management ranks. Moreover, the statistical test of complementary objectives highlighted the significant changes in time interval between the micro and macro perspective managers. It should
be noted that SMEs managers are independent from the other management groups. In addition to the managers’ desire for data collection, the author examines the favored TI by managers for HSE performance reporting.

![Time Interval at Input HSE Periodic Report](image)

Figure 4.9: Trend of input time interval at different organizational levels

### 4.3.2 Time Interval for Output HSE Periodic Report

Output reporting means issuing a performance report to the external organizations or the higher ranked management. A summary of favored TI for the output HSE performance reporting is presented in Table 4.3.

<table>
<thead>
<tr>
<th>(Day)</th>
<th>Board member</th>
<th>Chief Executive Officer</th>
<th>Senior Manager</th>
<th>Middle Manager</th>
<th>SMEs Manager</th>
<th>HSE Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>300</td>
<td>182</td>
<td>111</td>
<td>56</td>
<td>41</td>
<td>10</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>118</td>
<td>134</td>
<td>103</td>
<td>74</td>
<td>40</td>
<td>11</td>
</tr>
<tr>
<td>Variance</td>
<td>13950</td>
<td>18047</td>
<td>10590</td>
<td>5435</td>
<td>1576</td>
<td>113</td>
</tr>
<tr>
<td>Maximum</td>
<td>360</td>
<td>360</td>
<td>360</td>
<td>360</td>
<td>180</td>
<td>30</td>
</tr>
<tr>
<td>Minimum</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>7</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
According to the data in Table 4.3, the Board members are interested in the issues the HSE performance of the company in a period of 300 working days or approximately once a year. This rate for CEOs is approximately nine months or 182 working days. This rate for senior managers decreases to 111 working days, approximately a seasonal period. SMEs manager or contractor managers are supposed to publish their HSE performance reports during the period of 41 days, while the middle managers preferred 56 working days. The desired period for HSE managers to publish the corresponding HSE performances is ten working days. Figure 4.10 presents the similar trend to the trend presented in Figure 4.9.

![Time Interval at Distributed HSE Periodic Report (Output)](image)

Figure 4.10: Trend of output time interval at different organizational level

4.3.3 **Blue Time Analysis**

The desired TI for input and output reporting is different at managerial levels. To overcome the gap, BT is developed by the author and as optimized TI. Two important rules were considered in developing BT to simplify its calculation:

1. The priority between the report sender and report receiver is given to the receiver as it has a higher organizational rank, *Organizational rule.*
2- The working days and normal calendar days are equal as the companies worked full weeks (seven days), *Research primary assumption.*

BT has two characteristics. It links different periods of time of reporting and it should be linked with the business time line. Then, theses cycles should be adjusted in one time line to respect the other BT head on having one time line.

Different cycles have internal transitions and each cycle has to be run over the subsidiary cycles. It would be challengeable if each manager wanted to follow its cycles, as different cycles do not turn into each other. For example, in Figure 4.11, a cycle of eight days, 46 days, and 70 days did not have a common factor together. To solve this equation, the primary period of reporting was achieved from interviews with 108 managers. As shown in Figure 4.11, by the first rule (organizational rule), priority was given to the desire of the upper manager. Further, it would limit the time of reporting at subsidiary layers. On the other hand, the desire of the board for reporting is also considered as the desire of company to issue the business performances to stakeholders. However, the business output reporting needs for more investigation as the outside stakeholders were not studied in the current research.

![Figure 4.11: The time interval at input and output performance reporting](image-url)
Figure 4.12 is presenting the desired time of reporting on each managerial level by two linked gears. Each link presents a time for HSE performance report including the time for data collection and the time for performance reporting. In fact, Figure 4.12, presents the static condition of the performance communication network, in which managers are considered as segregated links. In the dynamic condition, the multi-gears must be assembled to generate business performances. The function of multi-gears must be adjusted within the business performance outcome. Considering the Pi as the desired time for data gathering by manager at level I, the number of X reports would be reported over the time period of C (business performance time interval).

\[ P_1X_1 = P_2X_2 = P_3X_3 = P_4X_4 = P_5X_5 = C; \{X_i \in \mathbb{N}\} \]
4.3.4 Organizing the Communication Plan

In contrast with the planning stream that distributed from top to bottom, performance reports at businesses would link lower levels with upper organizational levels, as illustrated in Figure 4.13. Simplified organizational direction from the bottom to the top levels is organized so as to support the requested time of reporting. Performance data is collected by the middle manager then sent to the senior manager. Senior manager perform data integration, producing a new report for Top Managers (CEO). In a similar way, the CEO would make a decision about the received data and then compile them into the format of interest for the board member. HSE managers are in charge of conducting the HSE performance communication networks in line with business strategies; however, managers need to take action to improve their performances by themselves.

According to the research, middle managers wanted to collect their HSE performances data every ten days and published it in 56 days. This time is close to that desired by senior managers interested in collecting data at a period of 41 days. So, the 56 declined to the gear with a size of 41 days. A similar connection was found between the desires of SME managers to publish at 41 days with the SM desire for data collection. Other adjustments could be found between the other managers, as presented in Figure 4.13.

BT is the adjusted time for HSE communication network for data collection. The gear size must be tuned up in which the gears moves smoothly with no interruptions.
Figure 4.14 demonstrated BT in number of working days at different management levels, extracted after data adjustment between ± 5%. The result highlighted that the BT interval at the executive levels are two, five, and ten working days, which are assigned to the HSE manager, SME managers, and middle managers, respectively. It should be noticed that SME managers are not considered part of management in large enterprises as they are independent. Moreover, BT between HSE managers and middle managers or between a contractor and middle manager is a common factor. At macro levels, BT for
senior managers, top managers, and the board are 40, 100, and 200 working days, respectively, with a maximum 5% time adjustment at the CEO level.

The first objective of the research was to determine the top 5 HSE performance indicators for each managerial level:

Figure 4.14: Adjusted Blue time for different management levels

4.4 Top 5 HSE Performance Indicators

The first objective of the research was to determine the top 5 HSE performance indicators for each managerial level:
4.4.1 Board Members Level

According to Figure 4.15, the most interested HSE performance indicators for Board members are: 1) PI 44 social contribution with a score of 2.2, 2) PI 20, HSE organizational culture with a score of 1.9, 3) PI 18 HSE awards with the same score of 1.9 attend at the second importance rank, 4) PI 41 Energy consumption with a score of 1.5, and 5) PI 5 Management review meeting indicator by a score of 1.4.

Discussion: According to previous sections, BT at this level is 200 working days. So, all investigated performance indicators should be able to report at least once during this period. 200 working days in companies with 10 hours’ work per day, is equal to one year on normal working schedule. All the mentioned top 5 indicators can be reported at a period of six months, unless the subject of HSE organizational culture. However, this measure could be reported annually, with output HSE periodic reports. The time for management review meeting, social contribution, and HSE awards can vary from seasonal to annual; however, this research highlighted that they should be held at least once each six months or sooner. The energy consumption rate could also be reported monthly and above; however, it should be reported each six months to the board.

![Average score given by board member for desired HSE PI](image)

Figure 4.15: The desire score given by board members
4.4.2 Chief Executive Officer (CEO) Level

The CEO in a company has the highest executive and strategic responsibility for steering the business toward its goal. The scores given by CEOs for each performance indicator are presented in Figure 4.16. The most preferred HSE performance Indicators at this level are:

1) PI 39, Total Hazard Potential, with a score of 2.24
2) PI 40, Mitigated Hazard potential, by score of 1.24
3) PI 17, employee participation rate with the score 1.18
4) PI15, Management review meeting with a score of 1
5) PI 23, Non-Injury Incident/Accident with a score of 0.94

Discussion: Two subjects were allocated to the metric indicators, THP and MHP. Moreover, one of their selections is the results-based indicator and one at the meeting and the last on workers’ HSE participation.

The BT for CEO is 100 working days, which is approximately six months at a normal working schedule. All of the requested PIs could be gathered during the period of a season. This outcome shows that the Management review meeting should be held on a seasonal basis to let CEOs monitor their responsibilities; however, its results may be published every six months. Of these indicators, only management review meetings may be requested by the upper level. The indicators of non-injury incidents, THP, MHP, and worker participation should be collected by CEOs within 100 working days.
4.4.3 Senior Management (SM) Level

SMs are the second most important rank in organizations behind CEOs. This group of managers has a significant role in supervising the large group of middle managers. Their commitment to HSE would have a great contribution to improving the company HSE performance. The desired score on each subject is demonstrated in Figure 4.17, in which the top 5 are:

1) PI 24, the number of total recordable incidents with a score of 1.56
2) PI4, the number of HSE planning meetings, with a score of 1.07
3) PI39, Total Hazard potential, with a score of 1.0
4) PI 3, incident investigation, with a score of 1.0; with the same rank with PI39
5) PI 15, unsafe conditions, with a score of 0.78

Discussion: SMs collect the HSE performance data each 40 working days, while they should send their report to CEO during the period of 100 working days. 40 working
days is the equivalent of a season at normal work schedule. All the selected PIs have the ability to be reported monthly.

Selecting these subjects highlighted that senior managers have concerns about incident occurrence, while they also notice follow up and finding root causes by incident investigation. Moreover, they are interested in the risk planning meetings in their businesses and in following up unsafe conditions removal. SMs are also interested in integrating the hazardous cases in the hazard cloud system, to monitor their safety performances.

On the other hand, they monitor the change of the total hazard potential of the company and on the subsidiaries or contractors, though THP.

4.4.4 Middle Management Level

Line managers, operational managers, or executive managers, called middle managers, are the other group of managers that face many challenges at the business front of operations and services. They have to comply with different aspects and standards in line with their functions, including technical specifications, financial
requirements, time schedule, HSEQ requirements, etc. On the other hand, they have to move their job smoothly and gently.

They have to describe their idea simply to convince the workers at the lower level and to present the performance of their team to the upper organizational level. This challenging task needs suitable indicators for decision support. Figure 4.18 presents a summary of the investigation on their top 5 selections:

1) KPI1, the number of toolbox meetings, with a score of 1.24
2) PI 15, the number of Unsafe Conditions, with a score of 1.19
3) PI 14, the number of Unsafe Act, with a score of 1.05 with the same score with PI4
4) PI 4, the number of HSE Planning meeting with a score of 1.05
5) PI 21, near miss incident with a score of 1.0

Discussion: The BT for middle manager is ten working days, which is equal to two weeks in a normal working schedule. It demonstrates the importance of close communication on HSE matters at the level of execution. Middle managers should send their HSE performance reports within a period of 40 working days to senior managers. In fact, they have enough time to implement their HSE plan in practice, prior sending their reports to the upper levels.

To control the top 5 selected subjects, they must be able to produce at least once per every ten working days. The number of unsafe acts and unsafe conditions and toolbox meetings can easily be reported at this cycle as they are part of daily operations. Again, the number of near misses or near hits can be reported based on weekly failures. HSE planning meetings could also be weekly. In fact, all selected indicators could be produced according to BT.
Selection of these subjects highlighted that middle managers will promote HSE in practice by increasing the toolbox meeting for their workers in line with intensifying HSE planning meetings. They monitor the hazards in their work environment by tracing unsafe conditions and unsafe acts while attending to the rate of near misses.

4.4.5 SMEs Management Level

SME managers (including many of contractor) must consider different situations and their resources to make decisions on resource allocation and to conduct the business operation in the execution. SME managers, in contrast to middle managers, have more freedom in decision making; however, the higher risk may collapse the business. They also may admit to adapting the company to challenges they are not prepared to encounter (Dominguez, 2010).

According to the data presented in Figure 4.19, the top 5 HSE performance indicators for SME managers are:

1) PI 40, mitigated hazard potential with a score of 1.29
2) PI 21, near misses indicators with a score of 1.21
3) PI 1, tool box meeting, with a score of 1.21, with same rank with PI21
4) PI 39, total hazard potential, with a score of 1.17
5) PI 6, HSE procedures by a score of 1.13

Discussion: The BT at the SME level is five working days, which is equal to one week in a normal schedule. They have to prepare their performance report in the period of ten days for middle managers or every 40 days for senior managers. They could send their report to middle managers if requested by them, but the desire of the SME manager is to publish their performance every 41 days, which is close to the time requested by senior managers. BT of five working days for HSE data gathering emphasizes their interest in controlling the HSE aspects of their business with a close look. Most of the desired performance subjects could be reported each five working days, except PI6. In fact, the number of produced or revised procedures is an unsuitable measure that matches the weekly time frame for measurement. In fact, preparation or revising of any procedure may last a few months depending on the team and not one week. Therefore, this indicator could not be accepted for this group. The author believes that the pressure of clients on their contractors to provide different procedures, may be the reason for this selection. The sixth selection with following specification is substituted by PI6:

5) PI17, employee participation, with a score of 1.04

This indicator could also be reported weekly, considering the limited workforce of SMEs. The research on SME managers or contractor managers highlights that they are interested in MHP and THP to know the amount of hazard potential in their company and the amount of mitigated hazard potential. They track the number of near misses while trying to improve HSE awareness by counting the number of tool box meetings and the number of their worker participants.
4.4.6 HSE Management Level

HSE managers are the other group of business managers in large enterprises other than SMEs, while few HSE managers are supervised by senior managers.

Figure 4.20 illustrated the score for top 5 HSE indicators on this group:

1) PI 7, frequency of HSE inspection, with a score of 2.44
2) PI 4, Incident investigation, with a score of 1.89
3) PI 14, unsafe act, with a score of 1.44
4) PI 21, the near miss incidents with a score of 1.33
5) PI 15, the unsafe conditions with a score of 1.11

Discussion: The BT Interval for HSE managers as the field HSE supervisors is two working days. Investigated performance indicator for this group, all could be produced in a frame of two working days. Frequency of HSE inspection, the number of identified unsafe acts, the number of unsafe conditions, and the number of near misses all could be collected within two working days by HSE managers in field. Incident investigation
requires few investigation meetings, in which the number of investigation meetings is the other interested subject by this group. It can be recorded every two working days and published before the end of ten working days to middle managers or to HSE departments at headquarters.

![Average Score Given by HSE Managers for Desired HSE PI]

**Figure 4.20:** The desired score given by HSE managers

### 4.5 Top HSE KPI

The third objective of this research was to determine the top HSE KPI by 1) Finding the top HSE KPI and 2) controlling the specification of KPI.

#### 4.5.1 HSE KPI Investigation

Finding the top preferred HSE KPI is done by calculating the score of each indicator in sight of macro perspective managers (board members, CEO, and senior managers). However, this priority is also being monitored in terms of scores given in overall perspective including all six management layers. Table 4.4, the scores given to all HSE performance indicators at micro, macro, and overall perspectives are presented. Indicators were sorted by overall score, from highest to lowest.
By drawing the score in the bar chart, Figure 4.21, it can be seen that PI 39 has reached the peak with around 40% higher than the second HSE performance indicator, PI40. The second and third HSE performance indicators obtain close scores, while they have approximately 20% higher than the fourth performance indicator. According to this Figure, PI 39, THP is the first candidate to be the Top HSE KPI with the highest score of 1.39. It followed by PI40, MHP with the score of 1.0 and then PI24, Total recordable incident frequency, with the score of 0.96. In fact, there is a significant difference between the first and the other indicators in the macro perspective.

Figure 4.21: The average score given by managers at Macro perspective
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</tbody>
</table>
To control KPI 39, the overall scores given by all managers are illustrated in Figure 4.22. This graph also highlighted that PI 39, with the score of 1.05, has the highest score in the overall perspective. The PI39 given score is around 20% higher than the second top score. Performance indicators, PI40 and PI24, are still on the second and third ranks.

According to Owe (2005), HSE KPI should be the strategic metric driver constructed based on the HSE operational drivers. THP is the symbol of total hazard potential in project, region, or company being calculated based on all identified unsafe act (PI 14) and unsafe conditions (PI 15) whether it lead to an incident or not. In fact, PI14 and PI15 may be generated based on risk assessment meetings or as a result of incident investigation. Therefore, THP and MHP could pass KPI specifications. The third top candidate, PI24, total recordable injuries is a results-based indicator and could not be HSE KPI. The fourth candidate was PI4, management review meeting could not be steered with operational drivers, so it could not meet the KPI specification. In fact, the
number of this meeting just will be built with the desire of top management and his timetable and not be made by operational drivers.

PI 40, MHP, and PI39, THP, have internal relationship; in fact, these are two sides of a business hazard cloud monitoring (total and mitigated).

Figure 4.24 also shows the placement of PI 39 in comparison to the other high rank PIs. The first three HSE performance indicators have the highest score of the two plotted trends. The dark green is the trend of score that given by managers with macro perspectives and the dotted line represents the score given by micro perspective managers. The light green line shows the overall perspective.

The complementary behavior trend between HSE indicators at two business perspectives (micro and macro) also confirms that the analysis was done correctly, as highlighted in Figure 4.23. The complementary behavior trend of the data between Micro and Macro groups was stated in different studies (Cline, 2003; Dopfer, 2004).

![Figure 4.23: Top ten HSE Performance Indicators by macro perspective managers](image)
The literature review in chapter 2 highlighted some important aspects of true KPI discussed in the following in relation to THP and MHP. Usage of THP without MHP could not provide an inaccurate estimation of HSE performances. In fact, THP presents the frame of needs (Total Hazard Potential that should be rectified according to the safety policy) and MHP highlighted the amount of mitigated hazard potential in this context. HazPoC\textsuperscript{29} is also the unit that employed for tracing the changed in both.

1- **Track changes**: HSE KPI must help managers to monitor changes of a safe operation. THP and MHP are made by all hazardous cases (act and conditions) that illustrated the cumulative risk confronted with management within the time. All business activities, workers, equipment, facilities, installations and work procedures at the same level, consist in different hazardous cases. Measuring of THP/MHP reflect the amount of hazard cloud changes.

<table>
<thead>
<tr>
<th>Macro</th>
<th>Micro</th>
<th>overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.39</td>
<td>0.70</td>
<td>1.05</td>
</tr>
<tr>
<td>1.00</td>
<td>0.72</td>
<td>0.86</td>
</tr>
<tr>
<td>0.96</td>
<td>0.59</td>
<td>0.78</td>
</tr>
<tr>
<td>0.70</td>
<td>0.78</td>
<td>0.74</td>
</tr>
<tr>
<td>0.31</td>
<td>1.09</td>
<td>0.70</td>
</tr>
<tr>
<td>0.26</td>
<td>1.15</td>
<td>0.70</td>
</tr>
<tr>
<td>0.65</td>
<td>0.69</td>
<td>0.67</td>
</tr>
<tr>
<td>0.39</td>
<td>0.87</td>
<td>0.63</td>
</tr>
<tr>
<td>0.54</td>
<td>0.69</td>
<td>0.61</td>
</tr>
<tr>
<td>0.22</td>
<td>0.93</td>
<td>0.57</td>
</tr>
</tbody>
</table>

\textbf{Figure 4.24: Upper and lower margin for selection of the top HSE KPI}

4.5.2 **KPI Specification Discussion**

The literature review in chapter 2 highlighted some important aspects of true KPI discussed in the following in relation to THP and MHP. Usage of THP without MHP could not provide an inaccurate estimation of HSE performances. In fact, THP presents the frame of needs (Total Hazard Potential that should be rectified according to the safety policy) and MHP highlighted the amount of mitigated hazard potential in this context. HazPoC\textsuperscript{29} is also the unit that employed for tracing the changed in both.

One HazPoC is equal to one risk level exposed to one person within 8 hours by one independent case (Torabi, 2015).
2- **Produced by the contribution of all:** HSE is the responsibility of all through any activities so the hazard cloud system is the outcome of all company members.

3- **Reliable to report continuously:** The performance report and the involved indicators shall be matched to produce a reliable report. THP is metric, able to produce within the continuous time cycles; however, frequency of cycles depends on the management layers and business plan for reporting.

4- **Integrity with the other management network:** Suitable KPI should be able to link with the performances of other managements to improve the performance of companies. It could have two meanings, 1) linking with other HSE management networks such as contractors, or 2) linking with other business performance networks such as throughput and finance. In the first view, it needs to connect the HSE performance of line managers and contractors at the front line of an operation to the CEO as the highest management rank for strategy planning. THP has the ability to connect different management layers.

   On the other hand, HSE risk links with other business risks (time and financial). So, THP could help managers monitor business risk.

5- **Have a significant relationship with result performance indicators:** The outcome of strategic performance indicators shall be adjusted with the result performance indicators. Any deviation between HSE KPI and the results-based indicators highlight the low validity in the measurement of KPI. Thus, the alignment with results will help the THP system be revised and calibrated in the short- and long term. However, usage of THP without MHP could not provide a true estimation for HSE performances. Both THP and MHP as HSE KPIs have the specification to adjust with the most favored results-based indicator. In this
study, TRC is found as the results-based indicator. Without this calibration, THP is just a numerical analysis with limited meaning in practice.

4.6 Complementary Analysis

Three different complementary studies were considered in this research.

4.6.1 Time at Input and Output Performance Reports

Should the time period for HSE data gathering and HSE data reporting be the same for a manager?

To answer this question, different cases of ties of input time and output time for each manager were aligned and, by using the Wilcoxon Matched-Pair Signed-Rank test, the following hypotheses were tested, in accordance with the detailed discussion in chapter 3:

\[ H_{05}: \text{There are no meaningful differences on Time for Input and Output performance reports for a manager.} \]

\[ H_{15}: \text{There are meaningful differences on Time for performance data gathering and performance data reporting to a manager.} \]

The rejection of the null hypothesis in narration means:

\[ Time \text{ at performance reporting is significantly different at input and output HSE performance reports for a manager.} \]

The mean time interval at Input reports and Output reports were 107 and 49, respectively, as presented in Table 4.5. The Wilcoxon test was performed and the differences in ranks were clearly highlighted in Table 4.6. Of 108 samples, 89 respondents emphasized that time interval at input scope should be lower than time interval at output scope; 18 highlighted the equal situation; one believed time intervals for reporting should be lower.
Table 4.5: Descriptive analysis of a nonparametric test on two dependent populations

<table>
<thead>
<tr>
<th>Descriptive Statistics</th>
<th>Differences on Report Scopes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Input safety periodic report</td>
<td>108</td>
</tr>
<tr>
<td>Output safety periodic report</td>
<td>108</td>
</tr>
</tbody>
</table>

The differences were calculated as “after weight minus before the weight of score.”

The statistic calculated for the test was $Z = -8.464$ and $p < 0.001$.

Table 4.6: Rank description and internal distribution of two different report scopes

<table>
<thead>
<tr>
<th>Ranks Wilcoxon signed rank</th>
<th>Differences on Report Scopes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>INPUT Periodic Report–OUTPUT Periodic Report</td>
<td>89$^a$</td>
</tr>
<tr>
<td>Positive Ranks</td>
<td>1$^b$</td>
</tr>
<tr>
<td>Ties</td>
<td>19$^c$</td>
</tr>
<tr>
<td>Total</td>
<td>108</td>
</tr>
</tbody>
</table>

By using SPSS and considering $p$ value less than 0.001, there is a significant difference in Time between input and output reporting as presented in Table 4.7.

Table 4.7: Wilcoxon test result of two different periodic reports

<table>
<thead>
<tr>
<th>Statistical Test p-value</th>
<th>Wilcoxon Signed Ranks Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymptotic significance (2-tailed)</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Thus, the null hypothesis would be rejected and the following hypothesis accepted:

$H_{15}$: There are meaningful differences on Time for performance data gathering and performance data reporting to a manager.
Discussion: Rejecting the null hypothesis through statistical test with more than 95% confidence, means that there is a meaningful difference in time of reporting by a manager from the point at which they collect their report until the time at which they publish their report. In fact, there is a redundancy of time. It means performance reporting could not be published directly after receiving HSE performance data from subsidiaries. In fact, the manager may have to collect performance reports from subsidiaries, then produce the new performance reports by considering significant time differences and collecting more than one performance report.

4.6.2 Time vs Organization Point of View (POV)

Do managers with different POV follow different time intervals at reporting?

The significant difference in the BT of two general points of views, the Macro and Micro perspective, were examined through statistical test. The following hypotheses were considered to address this question:

\[ H_{06}: \text{The distribution means of Time is the same across both Micro and Macro management perspectives.} \]

\[ H_{16}: \text{The distribution means of Time is significantly different across both Micro and Macro management perspectives.} \]

The rejection of the null hypothesis in narration means:

\[ \text{The Time for collecting HSE performance reports is significantly different by changing the managers’ point of view.} \]

Descriptive analysis of data was demonstrated in Table 4.8. The number of populations in these two groups differed slightly: 52 participants with a Macro management perspective, in comparison with 56 records of managers with Micro perspective. The mean of Time Interval for group with macro perspective was 86.51 while the mean at micro perspective was 37.3 days.
The Mann-Whitney U test was used to evaluate whether this difference is significant enough for a meaningful difference or not.

Table 4.9 shows the results of the Mann-Whitney test, in which the U statistic value is 359.5 with a p-value of < 0.001. Since this p value is smaller than alpha = 0.05, the null hypothesis is rejected.

Table 4.9: Mann & Whitney test result of management perspectives

<table>
<thead>
<tr>
<th>Ranks Mann &amp; Whitney test</th>
<th>Management perspectives in Input periodic report</th>
<th>N</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro Management Perspective</td>
<td></td>
<td>52</td>
<td>86.51</td>
<td>5190.5</td>
</tr>
<tr>
<td>Micro Management Perspective</td>
<td></td>
<td>56</td>
<td>37.3</td>
<td>2312.5</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>108</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

By assuming alpha = 0.05, the z value shall be less than −1.96, or greater than 1.96, to reject the null hypothesis. The outcome of this test, expressed $z = -7.9$, $p < 0.001$ led to rejection of the null hypothesis. Therefore,

$H_{16}$: The distribution means of time interval is significantly different across both Micro and Macro management perspectives at input periodic reports.

Discussion: The statistical analysis highlighted an important fact: that the time used for data gathering at the Macro perspective is significantly different to the time needed
by Micro Management. This fact is consistent with the other fact, that “time interval at indicator could be shorter than the time interval of reporting,” concluding that time interval of the indicator used in macro management should be different from the time interval of the indicator employed by micro management. Thus, using the same indicator for both groups requires having different time intervals for each group.

4.6.3 Social Impact Estimation of Using the Top HSE KPI

According to the discussion in chapter 2, the time interval of indicators (working hours) that managers choose to report should be lower than the time content of reporting. Three indicators were evaluated in this research with different time intervals. The first one was the Malaysian Incident Rate (MIR) reported by DOSH, the second one was Total Recordable Injury Frequency, TRIF, calculated in Malaysia by the author in chapter 2, and the third one was THP/MHP, which were found to be the top HSE KPI and being used by few Iranian companies. In this section, the author investigates the impact of using any of these indicators in Malaysian enterprises and the affected workforce by answering the time reliability of the performance report. According to the methodology, the desire of performance reporting set for the seasonal performance report. However, the percentage of enterprises and the covered workforces were estimated for a wide range (monthly to annually). Time contents for MIR and TRIF were considered based on the calculation discussion in section 2.6.4, while Time interval for THP/MHP was also collected from the internal reports at IOEC\textsuperscript{30}. The distribution of enterprises in Malaysia adopted from calculation in section 2.6.1.

4.6.3.1 Primary Reliability Analysis of HSE Performance Report

Performance report would be reliable if its time content spot was supported by the curve of the time interval of the involved indicator. Time interval curve for MIR and

\textsuperscript{30} Iranian Offshore Engineering and Construction, HSE annual report, 2012
TRIF drew on the Time interval matrix. Time content of reports was highlighted based on different time cycles and populations. It is necessary to note that seasonal periodic report was set as the tolerable period for HSE reporting.

The MIR rate in 2010 was 4.9 injured workers. This means that each case of injury (excluding considering commuters and occupational health and foreign workers) occurred on average by working of 408,000 hours. The curves for time interval of 408,000 worked hours as a representative of MIR was plotted in the time interval matrix as shown in Figure 4.25. In fact, a range of 380,000 to 430,000 worked hours was highlighted as an opportunity for MIR ± 5%.

A summary of distribution of Malaysian enterprises in 2010 is presented in Table 4.10, while the average workers of each sectors is presented in chapter 2 in Figure 2.18.

Table 4.10: Distribution of Malaysian enterprises at different sectors (Statistics, 2011)

<table>
<thead>
<tr>
<th>% of Establishments</th>
<th>Agriculture</th>
<th>Mining</th>
<th>Manufacturing</th>
<th>Construction</th>
<th>Services</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Company</td>
<td>0.32</td>
<td>0.02</td>
<td>0.27</td>
<td>0.43</td>
<td>1.64</td>
<td>2.7</td>
</tr>
<tr>
<td>Micro Company</td>
<td>0.57</td>
<td>0.01</td>
<td>3.26</td>
<td>1.30</td>
<td>69.75</td>
<td>74.9</td>
</tr>
<tr>
<td>Small Company</td>
<td>0.29</td>
<td>0.02</td>
<td>2.10</td>
<td>1.01</td>
<td>16.00</td>
<td>19.4</td>
</tr>
<tr>
<td>Medium Company</td>
<td>0.15</td>
<td>0.02</td>
<td>0.35</td>
<td>0.60</td>
<td>1.89</td>
<td>3.0</td>
</tr>
<tr>
<td>Total %</td>
<td>1.3</td>
<td>0.1</td>
<td>6.0</td>
<td>3.3</td>
<td>89.3</td>
<td>100</td>
</tr>
</tbody>
</table>
If a company wanted to have a reliable performance report by using MIR, it should meet the minimum number of workers mentioned in Table 4.11 at different periods of reporting. This table also classified its minimum based on different working schedules; however, this conclusion was based only on normal working hours.

Figure 4.25: Time Interval Matrix is justified by MIR at normal working schedule
Table 4.11: Minimum Populations needed for having a reliable report by using MIR ( = 408,000) (2010)

<table>
<thead>
<tr>
<th>Remarks</th>
<th>Time content @ 5 working days</th>
<th>Time content @ 7 working days in one shift</th>
<th>Time content @ 7 working days in two shifts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2448</td>
<td>1677</td>
<td>838</td>
</tr>
<tr>
<td>95% CI</td>
<td>2326_2570</td>
<td>1593_1761</td>
<td>796_880</td>
</tr>
<tr>
<td>Mean</td>
<td>816</td>
<td>559</td>
<td>279</td>
</tr>
<tr>
<td>95% CI</td>
<td>775_857</td>
<td>531_587</td>
<td>265_293</td>
</tr>
<tr>
<td>Mean</td>
<td>408</td>
<td>279</td>
<td>140</td>
</tr>
<tr>
<td>95% CI</td>
<td>388_428</td>
<td>265_293</td>
<td>133_147</td>
</tr>
<tr>
<td>Mean</td>
<td>204</td>
<td>140</td>
<td>70</td>
</tr>
<tr>
<td>95% CI</td>
<td>194_214</td>
<td>133_147</td>
<td>66_73</td>
</tr>
</tbody>
</table>

Percentage of Malaysian enterprises with a reliable HSE performance report at the normal working schedule is presented in Table 4.12. The minimum population needed by using MIR was achieved by considering data presented in Table 4.10 and Table 4.11.

Table 4.12: Percentage of Malaysian Enterprises with reliable HSE performance report by using different indicators at different cycles

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Time Interval</th>
<th>Monthly</th>
<th>Seasonally</th>
<th>6-Month</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIR</td>
<td>408,000</td>
<td>0.00</td>
<td>0.00</td>
<td>0.27</td>
<td>0.72</td>
</tr>
<tr>
<td>TRIF</td>
<td>199,000</td>
<td>0.00</td>
<td>0.27</td>
<td>0.72</td>
<td>3.03</td>
</tr>
</tbody>
</table>

Table 4.13 presents the percentage of the workforce (out of 6,963,973 workers) covered by different sectors in 2010.

Table 4.13: Percentage of workforce at Malaysian industrial sectors (Statistics, 2011)
The minimum population needed by Malaysian enterprises to have a reliable HSE performance report presented in Table 4.14.

### Table 4.14: Minimum Populations needed for reliable report by using TRIF

<table>
<thead>
<tr>
<th></th>
<th>Month</th>
<th>Seasonal</th>
<th>6-month</th>
<th>Annual</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1200</td>
<td>400</td>
<td>200</td>
<td>100</td>
<td>Time content @ 5 working days</td>
</tr>
<tr>
<td>95% CI</td>
<td>1140-1260</td>
<td>380-419</td>
<td>190-210</td>
<td>94-105</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>822</td>
<td>274</td>
<td>137</td>
<td>69</td>
<td>Time content @ 7 working days in one shift</td>
</tr>
<tr>
<td>95% CI</td>
<td>781-863</td>
<td>261-288</td>
<td>129-143</td>
<td>62-72</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>411</td>
<td>137</td>
<td>69</td>
<td>34</td>
<td>Time content @ 7 working days in two shifts</td>
</tr>
<tr>
<td>95% CI</td>
<td>390-431</td>
<td>130-143</td>
<td>65-72</td>
<td>32-35</td>
<td></td>
</tr>
</tbody>
</table>

According to Table 4.15, the reliable safety performance report just covers 16% and 26.4% each six-month by the MIR and TRIF, in turn. TRIF has the capacity to produce the reliable seasonal performance report at 16% of Malaysian workforces.

### Table 4.15: Percentage of Malaysian workforce who covered by reliable HSE performance report by using different indicators at different reporting cycles

<table>
<thead>
<tr>
<th>% of workforces</th>
<th>Indicators</th>
<th>Time Interval</th>
<th>Monthly</th>
<th>Seasonally</th>
<th>6-Month</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIR</td>
<td>408,000</td>
<td>0.00</td>
<td>0.00</td>
<td>15.99</td>
<td>26.41</td>
</tr>
<tr>
<td></td>
<td>TRIF</td>
<td>199,000</td>
<td>0.00</td>
<td>15.99</td>
<td>26.41</td>
<td>51.19</td>
</tr>
<tr>
<td>Total workforce Population, 2010:</td>
<td>6,963,973</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.6.3.2 **Social Impact Resulted by Top HSE KPI**

THP and MHP were used at monthly periodic reports in two of the studied companies. The line of 7,500 worked hours was plotted on Time interval matrix, and covers 30 workforce per 30 working days. In fact, THP has the least time interval of the HSE indicators; however, this could lead to unreliable reports in any working groups or any periodic reports.
As seen in Figure 4.26, the monthly report in companies with at least 50 workers and seven working schedules, could be reliable if they report THP. The close view in the turning point and boundaries are magnified in Figure 4.27. This graph indicates that medium-sized companies in the monthly report can use THP KPI at 7,500 worked hours. The micro company with populations up to five workers could not be covered by THP. Besides, the use of THP to report the performances of small companies with a maximum of 20 workers could lead to unreliable reports at monthly periods.

Figure 4.26 : Comparing the reliability of report by THP and TRIF
different cycles is presented in Table 4.16.

Table 4.16: Minimum Populations needed for a reliable report by using THP

<table>
<thead>
<tr>
<th></th>
<th>Month</th>
<th>Seasonal</th>
<th>6-month</th>
<th>Annual</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>45</td>
<td>15</td>
<td>8</td>
<td>4</td>
<td>Time content @ 5 working days</td>
</tr>
<tr>
<td>95% CI</td>
<td>43.47</td>
<td>14.16</td>
<td>7.8</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>31</td>
<td>10</td>
<td>5</td>
<td>3</td>
<td>Time content @ 7 working days in one shift</td>
</tr>
<tr>
<td>95% CI</td>
<td>29.32</td>
<td>10.11</td>
<td>5.5</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>15</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>Time content @ 7 working days in two shift</td>
</tr>
<tr>
<td>95% CI</td>
<td>15.16</td>
<td>5.5</td>
<td>2.3</td>
<td>1.2</td>
<td></td>
</tr>
</tbody>
</table>

As seen in Table 4.16, by decreasing the period of reporting, the amount of supported workforce increased. Besides, by changing the working schedule in a company, the
minimum population for a reliable performance report will be changed. Table 4.17 provides a summary of social impact of the research finding.

**Table 4.17: Changes at the percentage of business company with reliable HSE performance report before and after of using Top HSE KPI**

<table>
<thead>
<tr>
<th>% of enterprises</th>
<th>Indicators</th>
<th>Time Interval</th>
<th>Monthly</th>
<th>Seasonally</th>
<th>6-Month</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous Indicators</td>
<td>MIR</td>
<td>408,000</td>
<td>0.00</td>
<td>0.00</td>
<td>0.27</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>TRIF</td>
<td>199,000</td>
<td>0.00</td>
<td>0.27</td>
<td>0.72</td>
<td>3.03</td>
</tr>
<tr>
<td>Top HSE KPI</td>
<td>THP</td>
<td>7,500</td>
<td>0.3</td>
<td>6.4</td>
<td>25.1</td>
<td>26.4</td>
</tr>
<tr>
<td>Changes</td>
<td></td>
<td></td>
<td>0.3</td>
<td>6.2</td>
<td>24.38</td>
<td>23.37</td>
</tr>
</tbody>
</table>

| Total enterprises, 2010: | 662,939 |

As it shown in Figure 4.28, the use of the research finding would increase the percentage of the reliability rate in seasonal reporting in Malaysian companies. THP usage could improve approximately 24% in the number of companies with six-month and annual reporting.

![RELIABILITY OF PERIODICAL PERFORMANCE REPORT IN MY BY HSE INDICATORS](image)

**Figure 4.28: Portion of Malaysian enterprises with reliable reports by using different performance indicators**
The number of workforce was covered by the reliable performance report in terms of the social impact. Table 4.18 demonstrated the amount of workforce covered by THP in comparison with the other most common indicator in Malaysia.

Table 4.18: Changes in the percentage of business workforce being managed by reliable HSE performance report before and after of using Top HSE KPI

<table>
<thead>
<tr>
<th>% of Workforce</th>
<th>Indicators</th>
<th>Time Interval</th>
<th>Monthly</th>
<th>Seasonally</th>
<th>6-Month</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>previous Indicators</td>
<td>MIR</td>
<td>408,000</td>
<td>0.00</td>
<td>0.00</td>
<td>15.99</td>
<td>26.41</td>
</tr>
<tr>
<td></td>
<td>TRIF</td>
<td>199,000</td>
<td>0.00</td>
<td>15.99</td>
<td>26.41</td>
<td>51.19</td>
</tr>
<tr>
<td>Top HSE KPI</td>
<td>THP</td>
<td>7,500</td>
<td>3.88</td>
<td>19.06</td>
<td>80.76</td>
<td>81.30</td>
</tr>
<tr>
<td>Changes</td>
<td></td>
<td></td>
<td>3.9</td>
<td>3.1</td>
<td>54.35</td>
<td>30.11</td>
</tr>
</tbody>
</table>

Total workforce Population, 2010: 6,963,973

According to Table 4.18, employing THP would lead to an improvement of approximately 4% at monthly and seasonal periods. Besides, it can lead to more than 3% improvement in comparison with the MIR at monthly cycles. THP could dramatically increase the reliability in the number of covered workforces up to 80% at six-month recycles.

Figure 4.29: Portion of supported Malaysian workforces by reliable performance report at different HSE performance indicators
4.7 The Power of Methodology for True Estimation

The methodology of this research was designed by the author, as there was no similar existing study. To evaluate the effectiveness of the methodology and to prevent invalid results, the methodology of this research was examined according to the methodology mentioned in Chapter 3. The important question in this diagnostic test was whether the selection of indicators by experienced managers would be trustworthy or not. If so, to what extent could it be trusted? To control the true value align with the investigation, time interval was collected as an independent factor and as the controlling element.

In this research, six groups of managers were invited to choose the top five indicators, so the assumed positive items were 5*6, equaling 30. Time was also investigated by the interview for each management level as the controlling factor, by which one of them was rejected.

SME manager could not produce the procedures on the period of one week. However, they might be able report this indicator at the period of few weeks. PPV is defined based on the probability of distinguishing a true case to all diagnostic cases. This means the probability of true PI (30-1) out of all selected PI (30) is equal: 29/30 = 96%.

Rather than PPV, prevalence was defined based on the proportion of answers in the population, which has a condition or the ratio of HSE PI (5x6) per all HSE performance indicators (45x6 = 270). This is equal to 30/270 = 11%. In fact, by limiting selection to five, the chance of selection of each PI was decreased to 11%. The chance of finding the true answers improved from 11% to 5.9% (16 per 270). In fact, multi-selection of few subjects, limit the chance of selection to 5.9%.
CHAPTER 5: DISCUSSION

5.1 HSE Performance Network in Static Concept

The top 5 HSE subjects were presented at two POV for six different management levels.

5.1.1 Micro Perspective Managers

5.1.1.1 HSE Manager

Distribution of top 5 HSE performance subject was shown in Figure 5.1 for HSE managers including:

- Two from direct hazard measurement group by the subject of Unsafe act & unsafe conditions (PI14, PI15)
- One from meeting group by the subject of HSE risk planning meeting (PI4)
- One from management system group by the subject of frequency of HSE inspection (PI7)
- One from incident group by the subject of near miss

According to the BT = 2 working days, they have to collect their HSE performance data during a period of two working days. HSE managers (HSE head) have to send their HSE performance report after a period of ten days to the middle managers and of 40 days to the senior managers.
Distribution of top 5 HSE performance measurement subject by middle managers or junior manager was shown Figure 5.2 including:

- Two indicators from direct hazard group by the subject of unsafe act and unsafe condition (PI14, PI15)
- Two from meeting group by the subject of risk planning, and toolbox (PI4, PI1)
- One from incident group by the subject of near miss

They need to send their HSE performance report on period of 40 days to the senior managers. Base on BT = 10 days, they have to collect their HSE performance data every ten working days from subsidiaries.

5.1.1.3 SME Manager

Distribution of the top 5 HSE measurement subjects by SMEs manager was shown in Figure 5.3, including:

- Two subjects from indicators, THP & MHP, (PI394, PI40)
- One incident subject (near miss) (PI21).
- One subject from cultural measurement, worker participation (PI17).

Based on the BT = 5, SME managers have to collect data each 5 working days. They need to send their HSE performance report on period of 40 days to the senior managers or their client.

![Figure 5.3: HSE performance subjects interested by SME managers](image-url)
5.1.2 **Macro Perspective Managers**

5.1.2.1 **Senior Manager**

Distribution of top 5 HSE indicator subject by senior manager shown in Figure 5.4 are:

- Two indicators from meeting group (PI3, PI4), by the subject of HSE risk planning and incident investigation meeting.
- One from direct hazard identification group by the subject of unsafe condition (PI16).
- One from incident group by the subject of TRIF (PI24).
- One from indicator group by the subject of THP (PI39).

Based on the BT = 40, they collected has to collect their HSE performance data each 40 working days from subsidiary managers. Beside, SM has to be published by HSE performance report at the period of 100 days to the CEO. In fact, in two periods of reporting, they would have sent five complete reports to CEO.

![Figure 5.4: HSE performance subjects interested by senior managers](image)

**Figure 5.4:** HSE performance subjects interested by senior managers
5.1.2.2 Top Manager

Distribution of top 5 HSE indicator subject by the top manager was shown in Figure 5.5 including:

- One from meeting group by the subject of (P5) Management Review Meeting
- One from cultural group by the subject of employee participation (PI17)
- One from incident group by the Non-injury incident subject (PI23).
- Two from indicator group by the subject of THP and MHP (PI39, PI40).

The BT at CEO is 100 days. CEO has to collect their HSE performance data for the period of 100 working days from senior managers. CEOs have to publish the HSE performance report at the period of 200 days to the Board member.

![Top Five HSE Performance Indicators at different Organizational Levels](image)

Figure 5.5: HSE performance subjects interested by CEO

5.1.2.3 Board Member

Distribution of the top five subjects by board members is shown in Figure 5.6. In fact, the board is the final link of performance reporting in each organization.

- One from meeting group by the subject of Management Review Meeting (P5)
- Two from cultural group by the subject of employee participation and HSE awards (PI17, PI20)
- Two from social-environmental group including energy consumption and social contributions (PI40, PI44).

The BT at the Board is 200 days for HSE performance data collection. They published the business performance report at the time period requested by the stakeholders.

![Diagram](image)

**Figure 5.6: HSE performance subjects interested by board members**

### 5.1.3 Non-interested Subjects by Managers

According to Figure 5.7, there is no interest in training subject (PI11, PI12, and PI13) by managers as their top five. A wide range of incidents and indicators are not selected by any managerial levels (PI25 - PI38). None of the indicators with the management system subject are chosen by macro perspective managers (PI6-PI10).

There is no interest in environmental and social subjects, except by board members (PI41-PI45). HSE indicators with meeting subject, almost interested by every management level; however, safety committee meetings were selected by none of the
managers. Unless the board member group, each managerial level, choose one HSE indicator with a subject of incident with result base measures (PI21, PI23, PI24). Moreover, top managers, SME managers, and senior managers selected one or two subjects from the indicator group (PI39, PI40).

Figure 5.7: Top 5 HSE indicators aligned with subjects and management layers

Micro perspective managers almost have more attention to the direct hazard measurement (PI14, PI15), while macro perspective manager almost have attention to cultural subjects (PI17, PI18, PI20).
5.2 HSE Performance Network in Dynamic Concept

This research aims to establish an HSE performance network inside a company. The research finding in the previous section of this chapter leads to definition of time and subject of performance indicator for each management level, in a static concept. Now, in this section, the discussion focuses on the dynamic network concept. The discussion on BT in chapter 4, which leads to developing BT for different organizational levels, is presented in Figure 4.14.

To analyze the link between different indicators selected in the static concept, top selected were classified into six general zones for dynamic concepts (Figure 5.8). Zone 1 and 2 are operational drivers, which are preferred by the micro perspective managers. However, these indicators are not in favour of the macro perspective managers, specially top managers. Those reluctant on the top of the organization chart leads to poor commitment at the lower organisational level for follow up. Zone 3 is a cultural subject and just interested by top and SMEs managers. Although its indicator is a very important indicator, its production alone just benefits for publicizing with indirect effects on operational performances. Zone 4 refers to accident or near misses indicators, a results-based group. Zone 5 addresses the business total hazard content based on HazPoC, in which business hazard potential is continuously monitored. Moreover, zone 6 refers to the management review meeting in which, the last HSE outcomes are being reviewed and the objectives are set or revised. Zone 3, zone 4, and zone 6 are different from each other, of which, the results of zone 3 and 4 can be monitored at zone 6. However, the decision at zone 6 needs more proactive data. Zone 5 was the HSE KPI that acts as a compiler between micro and macro performance data. In fact, the outcome of zone 1 and zone 2 being compiled in zone 5 to present the macro performance. Similarly, the root cause of any incident investigation at zone 4 can also be imported to zone 5. The outcome of zone 5 would then be monitored in zone 6 for decision making.
The arrow lines in Figure 5.8 show the direction of data flow and how different data can be integrated into a new KPI to connect different managerial levels together. HSE inspections, unsafe actions, unsafe conditions, and the outcome of risk planning meeting can directly be integrated in business hazard potential (THP and MHP).

Figure 5.8: Data flow at performance communication network at dynamic concept
Figure 5.9 highlighted the top five indicators that interested by CEO while Figure 5.10 presents the interest of SMEs. They were the top manager with macro and micro perspective, in turn. As can be seen, the flow of indicators has the same pattern in both.

In fact, both patterns looking for one meeting subject, one incident subject, one participation subject, and two indicator subjects. The link between HSE performance subjects between different managerial levels are presented in Figure 5.11.
Both statistic and dynamic concepts are essential to empower the HSE commitment in business managers. Four groups of indicators could be found in the performance communication network.

The first group is KPIs, such as MHP and THP, which compile some group data from operational drivers to strategic drivers. The second group consists in indicators directly requested by different managerial level, such as unsafe conditions or near misses or the number of HSE planning meetings. The third group consists in indicators that nested together. In fact, they have an internal connection together. For example, the near misses subject has internal link with a total recordable injury case. The fourth group consists in performance subjects that solely interested by a group of managers. For instance, only a frequency of HSE inspection is preferred by the HSE managers.

Figure 5.10: Linkage of five important HSE performance subjects for decision making for SME managers
Similarly, the meeting indicators almost require special management levels for coordination of performances among subsidiaries.

Regardless of indicator groups, Figure 5.11 highlighted how the managers at different organizational levels linked together and what sort of measurement subjects interested them.

![Diagram of HSE performance network between different management layers; PhD research outcome: Torabi, M., Saeed, Engineering Faculty, University of Malaya, 2013](image)

**Figure 5.11: Connection of top five HSE performance indicators at organization communication network at dynamic concept**

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CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

The need for proper HSE indicators dates to documents from 1986. Finding the proper HSE indicators has been emphasized by researchers; however, no general principles have been defined to design the HSE communication network in companies. The occurrence of many recent incidents, even in pioneer companies, creates safety notices for the need for effective improvements in HSE performance communication networks. Improving managers’ commitment by employing the right measurement at the right time, flexibility in change management, overall business risk management, and enhancing the contribution of all were extensively highlighted in the literature review.

The literature review highlighted three overall risk assessment indicators: PSA, developed by IAEA, Risk Management Performance Indicator (RMPI) developed in Germany, and THP-MHP (the Hazard Cloud System), developed by an Iranian company. PSA is complicated and difficult for companies to use, while the RMPI has a good risk identification method. However, the integrated measurement, THP-MHP, combines two interactive risk-based indicators in a continuous time line over the normal distribution.

This study also tried to find a theory and philosophy for managers’ responsibility. Theoretical analysis by Douglas (1960) stated that workers should develop from irresponsible to responsible people by continuous observation and motivations. This transaction is supported by the Molla Sadra philosophy\(^{31}\), which stated the growth of people following four stages: 1- obtaining awareness, 2- assessing the facts, 3- self-management, and 4- leadership. According to Molla Sadra, people could move ahead

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\(^{31}\) Molla Sadra Shirazi, Iranian philosopher, (ca. 1050–1640)
between stages of responsibility, however, they could not return back to previous stage after moving ahead. They may just deny and ignore their responsibilities intentionally.

This study aimed to establish an HSE performance communication network in business companies to help managers understand their performances at the right time through the right indicators. This network would increase manager communication at different organizational layers in a company. This is supported by a theoretical social philosophy to raise people’s responsibility to be a leader, which indicates higher commitment to stakeholders.

Time and indicator were two important items to develop the business HSE communication network. Managers’ behavior at two organizational levels (micro and macro) was studied, and then the study concentrated on each of six management levels. The top 5 HSE performance indicators for each managerial level were investigated while the HSE KPI supports the connection between managerial performance indicators at dynamic concept. BT was developed for each managerial level to determine the cycle of communication between different managerial levels in the dynamic concept. The power of research methodology and social impact of the top HSE KPI should also be examined and maintained.

6.1 Research Conclusion

Of the 45 different HSE performance subjects investigated through interviews with 212 managers, just five top HSE subjects were found and controlled for at each management level.

At the micro perspective manager, the following trend was found:

1- The only interesting results-based subject of measurement were the near misses compared with the other ten incident measurement subjects.

2- Unsafe Conditions and Unsafe Acts (UC/UA) are the two most important subjects of measurement at the micro perspective managers; however, SME
managers substitute THP/MHP with these two. In fact, SME managers interested to the hazard cloud system to monitor the overall changes formed by UC/UA.

3- The meeting subject was nominated as the essential measurement subject. Middle managers and HSE managers are interested in risk planning meetings, while SME managers’ chose the toolbox meetings, which are more practicable.

4- Toolbox meetings are essential for middle managers of large enterprises; HSE managers prefer rate of HSE inspection, while the SME manager is interested in the rate of worker contribution.

For the macro perspective manager, the following trend has been found:

5- The senior manager is the core for the hazard cloud system as they linked middle and SME managers with the CEO and the business strategy.

6- THP is an interest of both senior managers and CEOs in large enterprises, requested also by SME managers.

7- Mitigated Hazard Potential (MHP) was only requested by CEOs, in addition to the THP.

8- HSE risk planning meetings are in favour of senior managers. Nevertheless, the CEO is looking for Management review meeting (MRM). It shows that SM concentrates on more technical meetings while the CEO just looks forward to more managerial meetings.

Top managers in large enterprises needs five measures to control the HSE performance network

9- THP and MHP were the most favored HSE KPIs in the business organization. However, top managers need to publish these indicators with one results-based indicator (Total Recordable Case). In fact, top managers could calibrate the hazard potential with one results base. The fourth important subject of
measurement is workers contribution indicator (Participation rate). It reflects how the business welcomes stakeholder criticism. Finally, the business HSE objectives have to be followed with one meeting indicator (Management review meeting).

10- THP data will be produced by operational drivers raised from subsidiaries, including unsafe conditions and unsafe acts, and the experiences achieved by risk planning meetings (risk assessment) or incident investigations.

Time Reliability of the performance report is critical. It is constructed by the time interval of the indicator and the time content of the report at the HSE performance communication network. A time interval of indicators must be equal to or lower than the time content of the performance report, which is determined by the number of workers and cycle of reporting.

11- The time content of reporting between the micro and macro managers is significantly different. This means that the same indicator could not employed by both management groups.

12- The time content for data collection and performance data reporting is significantly different. Thus, the manager could not publish the newly received performance report of subsidiaries.

13- BT as the optimized time for HSE performance data collection presents the following time at each management levels:

a. HSE manager at every two working days
b. Middle manager at every ten working days
c. SME manager at every five working days
d. Senior manager at every 40 working days
e. CEO at every 100 working days
f. The Board at every 200 working days
In Malaysian enterprises, 2010, MIR and TRIF were two lagging safety indicators introduced by the safety authority. Evidence for MIR and TRIF was probable after 408,000 and 199,000 working hours. Time interval for hazard potential system with the measure of THP was 7,500 working hours.

The reliability of safety performance reports using TRIF was estimated for Malaysian enterprises in 2010. All the monthly safety performances report that employing TRIF for measurement was found to be unreliable. The rate of enterprises with having a reliable safety performance report in seasonal and six-month reporting was less than 1%.

Substituting the TRIF with THP as the performance indicator leads to reliability of safety performance report in period of monthly, seasonally, and six-month reporting was raised to 0.3%, 6.4%, and 25.1% respectively.

The social impact of the research finding was also significant. Employing the performance indicators of the hazard cloud system (THP & MHP) would enhance the benefits of Malaysian workers from 0 to 3.88% (around 270,000 workers) on the reliable monthly performance report. This improvement at the seasonal period was the same (3.1%); however, there is a pick at six-month period of reporting (54.3%).

6.2 Recommendations

The following fields are suggested for further studies in the future:

1. Risk management techniques need to be extended to integrate the business, financial, and nonfinancial risks together.

2. Different performance measurement systems need to be examined in line with HSE strategy.

3. Time reliability in theory and practices should be investigated further.
4. The connection between supervisors and the performance network needs to be studied in more detail.

5. Modeling of THP and MHP through software development

6. MHP/THP validity with changes on the result-based needs for more data analysis.

7. Because of limited resources and difficulties in interviewing, this research is just limited to finding the top 5 HSE performance indicators through concentration of their subjects, which need further investigations between other groups of managers and indicators. This research does the best to classify a wide range of HSE subjects; however, many other indicators that are used by companies were not classified and included in this research.

8. However, the desired factors by business managers at different levels were just limited to some specific organization levels. Thus, the differentiation between managers and their responsibilities were not considered at this research and could be subject to future investigation.

9. This research focused on the arrangement of the top five HSE indicators that are of interest in different organizational levels; however, the efficiency of the introduced indicators in practice requires more analysis by researchers. How effective are they and what are the barriers that limit the effectiveness of introduced indicators should be explored further.
REFERENCES


knowledge management—including a few results. Research in Engineering Design, 19(2-3), 71-100.


UNDP. (2002). RBM in UNDP: Selecting Indicators, Signposts of Development (Ed.).


Weiss, K. B., & Wagner, R. (2000). PErformance measurement through audit, feedback, and profiling as tools for improving clinical care*. CHEST Journal, 118(2_suppl), 53S-58S.


# APPENDIX A

## Pocket HSE cards and answer sheet

<table>
<thead>
<tr>
<th>HSE Group Meeting 1</th>
<th>HSE Group Meeting 2</th>
<th>HSE Group Meeting 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Toolbox</strong></td>
<td><strong>Committee</strong></td>
<td><strong>Incident Investigation</strong></td>
</tr>
<tr>
<td><strong>Number of toolbox (Meetings have been held by supervisors in period of time)</strong></td>
<td><strong>% of Recorded Committee Meeting ( % of planned Safety Committee meeting against what planned)</strong></td>
<td><strong>Number of investigation (Incident investigated against reported incidents)</strong></td>
</tr>
<tr>
<td>Weekly/Monthly</td>
<td>Weekly/Monthly</td>
<td>Percentage Weekly/Monthly</td>
</tr>
<tr>
<td>A brief meeting at the start of the work stage gives everyone clarity about what needs to be done safely, controlling devices &amp; assessing the risk of changes. Workers say HSE problems and report any unsafe condition.</td>
<td>Appointed committee by Occupational Safety &amp; Health Authority in factories which gathered monthly to compile OSH requirements lead to reduce workplace injuries &amp; illnesses.</td>
<td>Meetings held by company to identify root causes and causal factors conducting the incidents or rearrangements and record corrective action for follow up to prevent recurrance.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Management System 7</th>
<th>Management System 8</th>
<th>Management System 9</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Management Review</strong></td>
<td><strong>HSE Planning</strong></td>
<td><strong>Work procedures</strong></td>
</tr>
<tr>
<td><strong>% of HSE target Achievement</strong></td>
<td><strong>Number of Risk Assessment Meeting (HSE meetings have been held by HSE Department)</strong></td>
<td><strong># of HSE Procedures (Written procedures modified/complete for execution by held)</strong></td>
</tr>
<tr>
<td>Annually</td>
<td>Percentage Weekly/Monthly</td>
<td>Number Weekly/Monthly</td>
</tr>
<tr>
<td>Formal, recorded meeting under the Chairmanship of the Facilities Manager that take place at regular intervals to discuss the functioning of the HSE management system and review of past performances and targets.</td>
<td>Number of registered HSE meeting in company including weekly meeting with contractors for hazard identification and risk management such as Job Safety analysis (JSA), Post JSA, HAZOP, HAZID, start up/ commissioning.</td>
<td>Written documents cover for routine or critical operations to ensure that all HSE barriers are in place without risks to the health of employees or environment including who may be affected.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency of HSE inspection</th>
<th># Inspections by PMT</th>
<th>External/Internal HSE MS audit Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency of HSE inspections by officers</strong> (hour inspected per 1000 Manhours worked in work area/department)</td>
<td><strong>Number of Closed HSE Items by Head</strong> (closed by project management team)</td>
<td><strong>System implemented score (Sum of all actual criterion scores (AC)/Sum of all maximum criterion scores (MC) x 100/1)</strong></td>
</tr>
<tr>
<td>Weekly/Monthly</td>
<td>Number Monthly/Special</td>
<td>Number Annual</td>
</tr>
<tr>
<td>HSE officers do HSE inspections to ensure that all HSE measures are in place in site and to evaluate any reported unsafe conditions, to control Unsafe act, to monitor changes in operation or permits in work area.</td>
<td>Workplace visibility tour by middle and senior managers in the work area once per month to observe real HSE performances &amp; HSE culture, to review and discuss comments and questions related the project and HSE requirements.</td>
<td>External/Internal HSE audit at least on semiannual basis might be carried out to assure the requested HSE Management system (MS) is in place by company or its contractors. The evaluation is conduct on MS elements.</td>
</tr>
</tbody>
</table>
### Management System

**# Minors/ Major NCR**

- **System Non conformance**
  - (Number of NCR as Minors/Major)
  - Number of observed lapse (Minor) & total number of absence or total breakdown of a required process (Major). The accreditation body requires that recertification audit be carried out every 3 years.

### Training & Competency

**HSE Matrix Training**

- **Man hours Training**
  - (%Scheduled training completed for HSE subjects Inside/Outside the Company)
  - To improve HSE awareness of employee regarding his/her main safe functions, different courses may assigned to. This matrix will organize essential safe skills for workers such as rigging, lifting, welding, cutting & others.

**HSE Induction**

- **Number of Induction**
  - (#Personnel attended in HSE induction for the first time or for annual re-validation)
  - HSE procedures/regulation, ERP, responsibilities, communication and reporting are inducted to all personnel in their arrival on company's premises. The Gate Pass is issued to only those who successfully attended.

### Training & Competency

**# Drills**

- **Number of Drills**
  - (Number of different type of drills carried out)
  - An exercise intended to train people in duties and escape procedures to be followed in case of emergency such as Fire, H2S, Evacuation, Confined space. Drills must be scheduled and conducted regularly.

### Hazard Control

**# Unsafe Act,**

- **Number of UA**
  - (Number of Recorded Unsafe Act)
  - Human factor on safety involve either the actions of a person or actions which were required but not carried out or were incorrectly performed such as Visitation on procedure follow up, Improper use or equipments, Failures & others.

### Hazard Control

**# Issued Permits**

- **Number of Permits**
  - (For different activities such as confined space, Hot work)
  - Permits are only issued when the necessary safety precautions have been taken for specific attribute or hazards which allow control center to know related information regard with safe operation.

### Hazard Control

**# Unsafe Condition**

- **Number of UC**
  - (# Recorded Unsafe Conditions in project/operation)
  - Lost primary barriers or lack of proper safety barriers for tools, equipments, environment or organizational aspects which could contributed to the hazard event in work environment.

### Contractors & Contributions

**# Employee participation**

- **Participation Rate**
  - (Number of direct report from employee on HSE matters)
  - The employees awareness and effectiveness of the HSE program depends on the participation and cooperation of employees in carrying out HSE responsibilities.

### Contractors & Contributions

**# Bids with HSE coverage**

- **# Pre-qualified Contract**
  - (Give HSE score for contractors selection in tender or pending invoices till HSE confirmation)
  - Tender should include provision to suspend work if the contractor does not observe the HSE requirements described in the contract. Any compensation arising out of the contractor job will be paid by the contractor.
<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HSE Awards</strong></td>
<td><strong>Total recognitions</strong> (Total amount of money distributed or number of people received awards) Means taken by company to motivate the staff &amp; supervisors by issuing/awarding them with the tokens/gifts monetary incentives to participate on hazard identification and more accountability/responsibility.</td>
</tr>
<tr>
<td><strong>HSE organisation Culture level</strong></td>
<td><strong>Organizational Culture</strong> (Culture level measured annually in 5 levels) The characteristics of organization is described at five level and typical descriptions are given for 18 dimensions that can be used to identify the current level of the organization in terms of HSE.</td>
</tr>
<tr>
<td><strong>Non-Injury Accident/Incident</strong></td>
<td><strong>Property Damage</strong> (Number of Non-injury Accidents/Incident Cases) Any unplanned event resulting in damage or loss to Property, plant Materials, environment and/or a loss of business opportunity such as fire, Env. incidents, Quality Incidents, vehicle Incident &amp; so on.</td>
</tr>
<tr>
<td><strong>Total Recordable Case</strong></td>
<td><strong>Total Recordable Injuries</strong> (Total number of wide range of incidents from minor recordable injury up to fatalities) Total number of injury or illness cases lead to Fatalities, Lost Work Day Case, Restricted Work Day Cases &amp; Medical Treatment Case.</td>
</tr>
<tr>
<td><strong>First Aid cases, FAC</strong></td>
<td><strong>Non recordable Injuries</strong> (Number of minor injury cases treated by first aider or equivalent) Number of cases of minor work injury or illness such as cleaning minor cuts &amp; etc, which no need to medical services. This factor is not considered in TAC.</td>
</tr>
<tr>
<td><strong>Medical Treatment Case (MTC)</strong></td>
<td><strong>Medical Treatment</strong> (Number of Medical Treatment Cases of injury or illness) Medical treatment beyond First Aid, e.g., wound closing &amp; prescription medication &amp; removal of foreign material that is embedded in the eye or diagnosis of cancer, chronic disease, a cracked bone or etc.</td>
</tr>
<tr>
<td><strong>Restricted Work Day Case (RWDC)</strong></td>
<td><strong>Injuries with Restriction</strong> (Number of injury in which employee keeping from doing the routine functions) The case does not have any days away from work, but has days of restriction. If a case either has one day away from work, or both &quot;restriction and absence injury&quot; should be recorded as LWDC not RWDC.</td>
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<tr>
<td><strong>Lost Work Day Case (LWDC)</strong></td>
<td><strong>Injury with lost time</strong> (Number of injury in which employee not fit to perform any work at any time after occurrence) Number of Cases in which an employee was absent of scheduled work because of work illness or injury and does not include the day of incident and does not cover fatalities case.</td>
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272
<table>
<thead>
<tr>
<th>Incidents</th>
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<tbody>
<tr>
<td><strong>Lost Time Injuries (LTI)</strong></td>
<td><strong>Severity of Lost Work Day Case, LWD Severity Rate</strong></td>
<td><strong>Days Away or restricted or Transferred duty, DART</strong></td>
</tr>
<tr>
<td><strong>Injuries with Lost Time</strong> (Total Case of Fatalities or lost work day case, LWDC)</td>
<td><strong>Severity of LTIs</strong> (Average Days lost per Lost Work Day Case, LWD)</td>
<td><strong>Frequent &amp; important incidents</strong> (Combination number of Cases of LWDC &amp; RWDC)</td>
</tr>
<tr>
<td>Number of Cases lead to at least one day off work till death because of work illness or injury. It does not include cases with no lost days such as MTC or RWDC.</td>
<td>Mathematical calculation that describes the number of days lost experienced compared to the number of incidents experienced.</td>
<td>Cases that involve Lost time, or days of restricted work activity or job transfer, or both. But not include fatalty cases.</td>
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<tr>
<th>Indicators</th>
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<tr>
<td><strong>Lost Time Injury Frequency, LTIF</strong></td>
<td><strong>Fatality</strong></td>
<td><strong>DART Rate</strong></td>
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<tr>
<td><strong>Frequency of Lost time incidents</strong> (Number of incident cases cause lost time/death per 1,000,000 worked hours)</td>
<td><strong>Number of Death</strong> (Number of workers lose their lives to work related injuries)</td>
<td><strong>Frequency of DART incidents</strong> (Number of incident cause Lost time/restriction per 200,000 worked hours)</td>
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<tr>
<td>The number of lost time injuries (fatalities + lost work day cases) per 1,000,000 work hours. The constant may be changed from company to company.</td>
<td>Cases that involve one or more people who died as a result of a work-related incident or occupational illness.</td>
<td>Calculated based on (N/EH) x (200,000) where N is the number of cases, EH is the total number of hours worked by all during the year, and 200,000 is the base for 100 employees which may change.</td>
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<th>Indicators</th>
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<tr>
<td><strong>Total Recordable Injury Rate</strong></td>
<td><strong>Fatality Accident Rate (FAR)</strong></td>
<td><strong>Fatality Incident Rate (FIR)</strong></td>
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<tr>
<td><strong>Total Recordable Case Rate</strong></td>
<td><strong>Fatality Accident Frequency Rate (FAFR)</strong></td>
<td><strong>Fatality Incident Frequency Rate (FIFR)</strong></td>
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<td><strong>Frequency of recordables</strong> (Rate of occurrence of recordable incidents per 1,000,000 Man hours)</td>
<td><strong>Frequency of fatality</strong> (Rate of fatal injury per 100,000 workers (UK), 100,000,000 Manhours(OGP))</td>
<td><strong>Frequency of incident with fatalities</strong> (Rate of fatal incident per 100,000 workers (UK), 100,000,000 Manhour(ogp))</td>
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<td>Rate of recordable workplace injuries, normalized per 100 workers per year. Recordable means fatalities, lost work day case, Restricted work case and MTC. The constant may change in companies.</td>
<td>The number of fatalities of company/contractor per 100 million hours worked. This indicator may called Recordable Fatality Rate by some companies. Constant is different in companies.</td>
<td>The number of incidents caused to fatalities in company/contractor per 100 million hours worked.</td>
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### Environment Indicators

**Direct GHG Emission**

- **GHG Emission**
  - (Total amount of GHG Emissions in CO2 equivalent)
  - Total quantity of GHGs released to atmosphere at a specific time in CO2 equivalent covering emission of CH4, CO2, NOx, CFCs, HCFCs & etc.

**Process Safety Events Rate, PSE**

- **PSE Incident Rate**
  - (Ratio of Lost Primary Containment (LOPC) for non/dangerous material per 1 million work hours)
  - In process industry, incidents result to either lost time injury, Fire with direct damage more than 25,000$ , Chemical release and environmental impact beyond its threshold per 1 million worked hours.

### Process Safety Incident Severity Rate (PSISR)

- **Weighted rate for PSE**
  - (Ratio of cumulative severity-weighted rate of PSE per 200,000 Work Hours)
  - Total severity score for all PSE incidents x 200,000 per Total employee, contractor & subcontractor work hours. The constant may change in companies.

### Total Hazard Potential, THP

- **Maximum Hazard Rate**
  - (Demonstrate the Highest hazard potential weekly in operation/project per 200,000 work hours)
  - Total number of Riskcase which produced by accumulation of risk within all assets (Process, equipments, People, environment) per 200,000 worked hours.

### Social Contribution Expenses

- **Amount of Contribution**
  - (Million $ or Equivalent on social responsibilities or number of local people trained or fostered)
  - Contribution on Local community conferences, volunteer service centers, Training, Employment, Health care & etc in nearby society.

### MHP; Mitigated Hazard Potential

- **Risk Transition Rate**
  - (Total amount of Mitigated Hazard which can be drawn per 100,000 Hazard Potential)
  - The ratio of Riskcase mitigated per 100,000 of Total Hazard Potential which indicate the overall practices to improve unsafe conditions/Unsafe Act.

### Waste Discharge Load

- **Discharge Wastewater**
  - (Total wastewater Load discharged in population equivalent)
  - Amount of organic biodegradable load generated in operation divided by 60 g (BOD5 of one person per day).

### Recycled, Reused and Recovered Materials

- **Amount of Recycling**
  - (Tonnes of waste prevent from sending to landfill for disposal by 3R)
  - Amount of Hazardous/Non Haz. waste recycled, reused, recovered (3R) from waste stream.

### Energy Intensity

- **Energy Consumption**
  - (Energy consumption ratio per gross domestic product or other industry output such as Sales, freight ton-miles, GDP as economic output)
  - It is measured by the quantity of energy required to perform a particular activity (service), expressed as energy per unit of output or activity measure of service.
### APPENDIX B: Top 5 HSE Performance Indicators introduced by different managers within Interview

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**HSE**

Managers top 5 selected indicators at different managerial levels

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*NC: Not Selected*