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A Behavior- and Observation-Based Monitoring Process for Safety Management

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The objective of this paper is to demonstrate that a combination of a behavior-based monitoring process—using an at-risk behavior and unsafe condition observation system—and an observation-based safety adherence monitoring process that can indicate the compliance level with well-defined and agreed safety critical aspects and operational practices and procedures will be an effective safety management tool. This tool herein described represents a particular case, developed by a Praxair Inc. subsidiary in Brazil. Other safety surveillance systems usually adopted in industrial environments can rarely be used on construction sites. They also do not share information, knowledge and skills among the safety staff and other professionals invited to observe, usually covering specific tasks or specific professionals only, not a complete working area, which causes functional observing and monitoring limitations in terms of capturing behaviors and environmental safety issues. This tool also offers a wide range of learning opportunities and continuous improvement.

risk behavior-based/monitoring system management tool safety observation

1. INTRODUCTION

Preventive objectives take human and economic issues into account, and the paths and methodologies adopted for this process have the capacity to influence the attitudes of personnel and, consequently, create organizational safety culture improvements [1], whose critical factors are well known [2].

Safety is not a product itself, but the result of all work processes in place for every activity, system, facility, or environment. The experience gathered on engineering safety indicates that incidents and injuries can be avoided. The development of theoretical knowledge and the practice accumulated, principally since the beginning of the 20th century [3, 4, 5, 6 7, 8], show that these events have common basic or root causes [9]. Actually, they have the same common basic "mechanism", shaped by the combination of an at-risk behavior—defined here as any unnecessary unsafe action or hazardous exposure [10]—and unsafe conditions, such as any potential environmental hazard. This mechanism, like any other, allows an objective and technical interference in its "structure", to avoid that incidental events take place. Therefore, it is necessary to develop and use an objective prevention system to observe and anticipate the occurrence of risky behaviors and unsafe conditions, as well as to promote environmental monitoring of these fundamental safety aspects

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to guarantee the effectiveness of the safety management system in place [11, 12].

From a practical standpoint, any accident with very severe injuries can be the result of incidental events without any specific condition requirement. It makes us immediately think that these injuries would not have occurred if we had eliminated those incidental events. Although this is logical, we shall add one special perception: even before those incidental events took place, there was a vast amount, specific number unknown, of at-risk behaviors and unsafe conditions that afforded and caused them. Therefore, preventing the occurrence of these initial factors would promote the extinction of any incidental event and its consequent injuries. In other words, an incidental mechanism can be defined as unsafe conditions set in motion. Any safety management strategy aiming to eliminate injuries or even incidents—which may become an accident depending on one centimeter or one second—shall concentrate efforts on eliminating at-risk behaviors and unsafe conditions from working environments, as well as creating and promoting an enriched safety culture, by training, improving participation, motivation by example, etc.

During the last century, some new concepts were incorporated to the original Heinrich's domino model [13], principally regarding the behavior-based approach to explain at-risk behaviors and the creation of unsafe conditions: the operational discipline idea, and the contribution of psychology and medicine to safety aspects, helping to achieve a better understanding of human errors. But even these new concepts preserve the original idea that an incidental event has immediate causes linked to unsafe conditions—usually more than one—and an at-risk behavior. The understanding of the foundations of behavior—especially about human errors and all human factors studies [14, 15, 16, 17]—is absolutely necessary to establish this safety process and the behavior-based safety approach in our work processes. Changing a culture is not an easy task [18]. Actually, it demands great effort, time, open mind, and a well-planned and balanced combination of knowledge, caring and hope.

This case study tries to demonstrate that a safety management system based on efficient safety management tools for the behavior-based monitoring of working areas for construction sites and also mechanical industries can anticipate unsafe conditions and at-risk behaviors, on monthly basis, for the site management team to interfere by applying preventive actions to reduce incident rates and to certify site safety adherence to the work processes in place [19].

2. INCIDENT CLASSIFICATION

Sometimes, the terminology may become an issue in completely understanding a specific theory or a new work process. It is important to consider that we use OSHA's (U.S. Department of Labor Occupational Safety and Health Administration) incident and injury classification for the purpose of this study due to the research developed in a global company with the main office in the USA.

3. THE WMGI/PRAXAIR CASE

Although this safety management tool can be implemented in any industry or construction site, the system described here was originally developed and used at White Martins Gases Industriais (WMGI; Praxair's GSS[1] group in Brazil) construction sites for WMGI/Praxair industrial gases facilities in South America, which encompasses two Brazilian mechanical factories (FEC[2] and FATRAN[3]) in Rio de Janeiro, Brazil, where this tool has also been implemented.

This process began in December 2000. There were three different phases, each representing

[1] GSS is Praxair's Global Supply System group, which provides engineering and technical solutions for the corporation worldwide.
[2] FEC—fabrication and maintenance, and field erection of Cold Box—the air separation column, which is the core part of an industrial air separation plant—cryogenic tanks, and production skids.
[3] FATRAN—truck and trailers fabrication and maintenance.

an important step in configuring this tool. The first was defining safety criteria and requirements that all employees and contractors working for WMGI would commit to. This was actually the most important phase because it represented the company's philosophy in terms of injury prevention, described by the safety key performance indicators (KPIs), and the approach the company adopted to achieve these safety goals for the two working environments, construction and mechanical factories [20, 21]. This phase was completed with the edition and full implementation of safety handbooks (construction and factories), with specificities for each environment. The second phase covered the implementation of the safety behavior-based observation system. Actually, it was a behavior-based observation process focused on at-risk behaviors and unsafe conditions in the working area, aiming at supporting and giving feedback to the field supervisor. The third phase, the most recent one, regarded a safety adherence observation system, which is capable of demonstrating all efforts developed by employees and contractors to achieve safety goals, relative to compliance with safety requirements established in the handbooks. This phase defined a new safety process performance indicator (PPI) for WMGI [22, 23]. For a better understanding of this process, a synthesizing diagram is displayed in Figure 1, and a description of each implementation phase and the results obtained is presented next.

3.1. Phase One: KPIs and Safety Handbooks

The company's safety management system has specific goals called key performance indicators (KPIs). Although they always mean

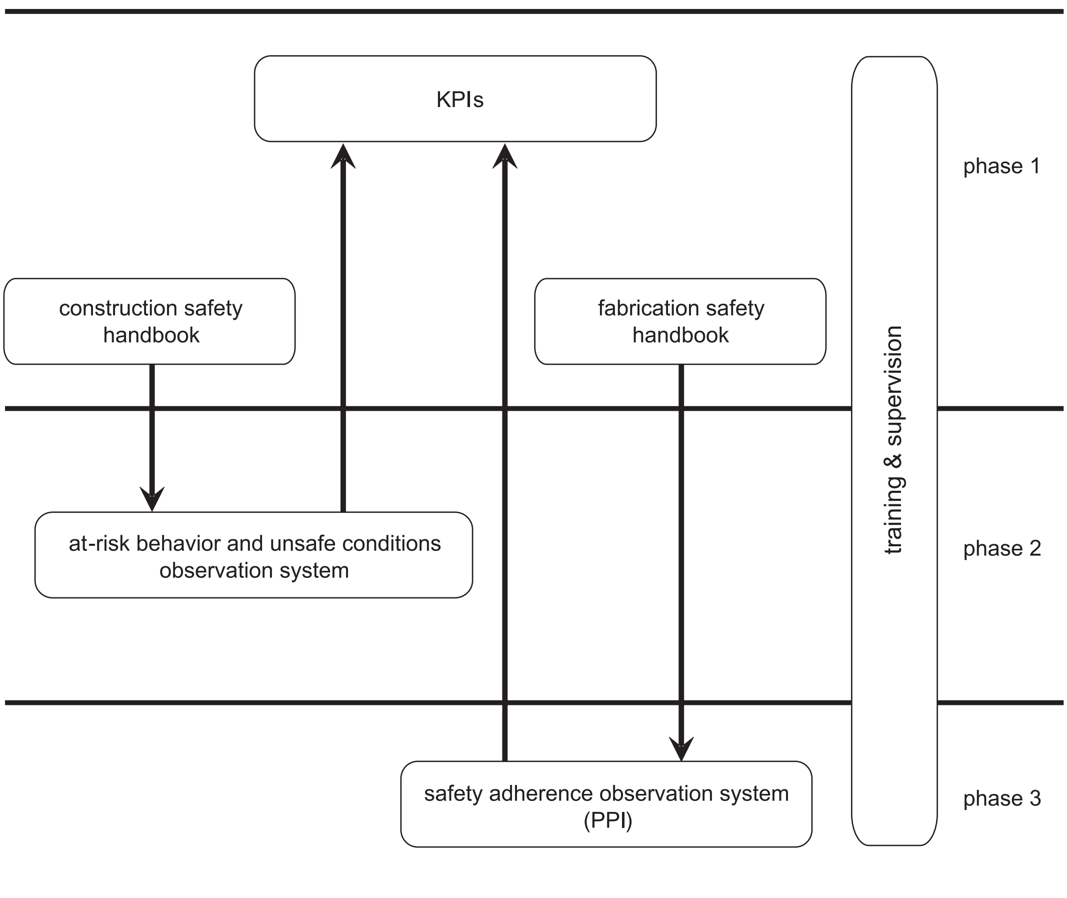

Figure 1. Safety management tool diagram. *Notes*. KPIs—key performance indicators, PPI—process performance indicator.

failure, because they indicate incidents and injuries that occurred at the work sites, they also establish a target aim or a premium for the team effort. Safety KPIs cannot be subjective; on the contrary, they need to be clearly known and understood as a goal to be reached [24]. As a worldwide corporation, Praxair establishes these KPIs on a global basis, but every international region will work on its individual results. They reflect regional major injury rates per 200 000 human-hours, monthly, which include recordable injury incidents (RII)—injuries classified as non-lost workday cases—and lost workday cases.

Table 1 shows the Praxair/GSS recordable accident rates, considered KPI targets for two different Praxair/GSS working areas: (a) contractor expresses construction activities usually performed by third-party companies with Praxair team supervision; (b) manufacturing refers to FEC and FATRAN factories, including WMGI employees and contractors.

TABLE 1. Safety Key Performance Indicators (KPIs)

Working Areas	KPIs*
Safety performance: contractor	
recordable injury incident	0.20–0.25
lost workday cases	0.05–0.10
Safety performance: manufacturing	
recordable injury incident	0.20–0.25
lost workday cases	0.00

Notes. *—rates per 200 000 human-hours; recordable injury incident = non-lost workday cases + lost workday cases.

Two safety handbooks were developed, the GSS construction safety handbook for construction sites [25], and the FEC/FATRAN safety handbook for the two mechanical factories [26]. The intent of this split was to address the specificities and different requirements in terms of teams and activities. The two mechanical factories used to have a majority of WMGI employees as a working team, using contractors to face workload variations. However, the WMGI/GSS group does not perform constructions, but outsources (contracts) for this job, performing their contract administration and work execution during the short time of their different construction phases from excavation, through civil construction, to mechanical and instrumentation field erection [27]. These handbooks were translated into Portuguese and adapted to meet Brazilian law and standard requirements. The main objective was to establish the safety criteria for each activity and the work process to be followed in terms of safety observations and audits to guarantee safety adherence.

3.1.1. Construction Safety Handbook

This handbook was originally designed to provide a tool worldwide for Praxair personnel in their effort to manage safe construction. While the structure of this document is geared to Praxair's capital construction, the process described here can be applied to any contract, which includes an annex called contractor rules for construction safety (RULES), which establishes all safety requirements for outsourced construction working at a Praxair site. The construction safety strategy is to guide the implementation of prevention through planning, contract administration, and management of work execution. The basis for outsourcing compliance to safe working practices is a regulatory requirement of the work they are performing. Expectations must be set during project planning and at contract release. Contractors must be qualified and selected for the work assigned. Each project must have a Praxair project safety plan developed and in place ensuring that steps are followed. Therefore, these RULES shall be issued to all contractors during the bid phase so that they take all these requirements into consideration and also produce a site specific safety plan detailing how they will perform work safely prior to starting a project. Each contract must include RULES as a basis for managing the contractor for safety. Diligent use of this Safety Handbook by Praxair/WMGI supervision, and follow-up, will help ensure that management is effective.

The basis for achieving this result is in the contract itself. Therefore, the Construction Safety Handbook has six sections for which the following steps need to be accomplished:

- Section One establishes overall work processes and administrative requirements. It is important that Praxair and contractor teams review and understand both the Praxair project safety plan and the contractor site specific safety plan upon visiting projects;
- Section Two covers observations to be planned and conducted during the work to identify hazards and at-risk behaviors, communicate and document them. Documentation of findings, action, and performance will assist Praxair in the ongoing administration of a given contractor;
- Section Three presents an alphabetical list of issue areas where current work may be underway. There are small checklists for each topic (58 total) as a first approach to certify safety compliance on fieldwork. Using the site schedule, plan, and contract, Praxair and contractor teams can determine which requirements apply to a given project and take actions as described below:
  - select the activity underway or program to review (e.g., stairs, scaffolding, housekeeping, confined space, cranes, fire protection);
  - use the questions provided on the selected topic to observe the activity. In each case, these questions should all be answered affirmatively, demonstrating safety compliance;
  - note the number(s) assigned to the topic observed if you wish to observe further and require more detail, question methods in use at the time of your observation, or whether answers are to the negative. If any one of these is true, proceed to Section Four and locate the corresponding checklist. If they are affirmative, move on to another topic as planned.
- Section Four provides checklists (the same topics as in Section Three) with greater detail on what safety precautions should be taken for the topic selected. These checklists do not provide all requirements in the subject area or cover every possible method that may be used. They provide guidance of the minimum requirements of what must be done to accomplish the subject area safely. Other source documents, experience or procedures can be used if the hazard so warrants. However, these are the areas where contractors are contractually obligated to comply with. If there is any disagreement of the points identified in the checklists, a copy of RULES is provided at the back of the handbook for easy reference. The topic number assigned in Sections Three and Four corresponds to the paragraph number for that topic in RULES. These requirements are contractually bound and, at this point, disagreements should be addressed on that basis;
- Section Five describes the process to follow when conducting a planned assessment of the facility or project;
- Section Six contains the best practices for projects. This information is provided as a guide to assist the project in execution, and detail highlighted high-risk areas requirements with solutions.

3.1.2. FEC/FATRAN Safety Handbook

WMGI has adopted an operating policy to conduct business in a manner that protects the safety and health of all team members. The highest priority is placed on establishing and maintaining a safe and healthy working environment, and on eliminating work-related injuries and illnesses. On that basis, the safety fabrication handbook was originally written in Portuguese to provide a tool for WMGI employees and contracted personnel in their effort to address safety aspects of each activity of factory workers, according to Brazilian law and standard requirements.

A pocket version was distributed to factory personnel (employees and contractors), and they were all trained to understand the safety requirements and the use of the handbook as a guide to daily activities, expressed in 52 safety topics, like personal protective equipment, lock-out/tag-out procedure, confined spaces, moving cranes, welding, and also contractor and supply safety. This pocket handbook is supposed to be carried by everyone inside factories as a helpful tool for safety aspects. A complete version of the handbook was developed for fabrication supervisors and management teams, including two more sections, which described safety requirements for each factory activity, as presented in the pocket version, with a similar philosophy adopted in the construction safety handbook, regarding the checklists of sections 3 and 4. Therefore, factory supervisors and management personnel—actually WMGI employees—can use these checklists for observations to verify compliance with safe working practices, and management of the work they are performing inside shop floors, or at the field assembling and maintenance.

3.2. Phase Two: At-Risk Behaviors and Unsafe Conditions Observation System

The safety strategy is to manage implementation of prevention through planning, workers' administration, and management of work execution. Behavior observations of contractors and employees shall support the safety strategy. We can and must observe for safety; however, observations must ultimately address the management system intended to prevent any at-risk behavior and unsafe conditions observed.

There are two important aspects a safety observation system should fulfill to achieve success: effective observation must be observation of behaviors of people performing their work and management's control of that work; and observation with respect to safety must be narrowed to observation of existing hazards—represented by at-risk behaviors—and potentially unsafe conditions as they relate to people.

This second phase started at FEC and FATRAN factories' shops as a trial of a behavior-based safety observation system and revealed itself consistent during 2001. At the beginning of 2002, this behavior-based safety observation system was adapted for construction sites with the same approach and results. For both working areas, the same main criteria were implemented:

- safety supervision personnel at the sites shall conduct the system, i.e., safety technicians from WMGI and contractors, and GSS site supervisors. They are trained to understand the safety requirements and the observation system methodology to be facilitators and its focal points;
- construction sites need to have a minimum schedule of three months to apply this safety observation system. From a practical standpoint, less than three months would create useless information for the site's safety staff regarding the dynamism of a small construction activity, i.e., when the first month observation report would be sent—probably regarding the civil construction phase—there would be nothing to do at the site, because this phase would have been actually concluded;
- two observations a week (minimum) per site shall be conducted to generate enough data for a monthly basis analysis and report;
- observations have to be done at least in pairs, i.e., the safety technician shall invite another professional at the site to join him/her for each session. From a practical standpoint, this guest can be anyone working or visiting the site—an administrative or technical employee or contractor. The main idea here is to gain a cross-training session considering the more accurate safety skill and knowledge of the safety staff. This would certainly provide safety training for the invited professional. On the other hand, though, this guest's specific skills or knowledge (or at least a fresh look on routine activities) would represent specific learning for the safety supervision. For example, an experienced electrician might detect safety issues on site installations or during electrical practices that the safety professional would not be trained to identify;
- observers shall use a specific protocol report, which will be an observation report of at-risk behaviors and unsafe conditions seen and corrected during each session. This protocol is divided by different standardized site observation areas. Table 2 shows these areas for a generic construction site and for FEC;

TABLE 2. At-Risk Behavior and Unsafe Conditions Observation System Protocol's Area Separation for Construction Sites and FEC

Protocol's Observation Area	Construction Site	FEC
1	main construction area	cold box shop[e]
2	pipe shop[a] for contractor #1	tanks shop
3	pipe shop for contractor #2[b]	VPSA shop
4	administrative area[c]	preparation shop[f]
5	backup area[d]	cutting shop

Notes. FEC—cf. footnote 2 on p. 408; VPSA—vacuum-pressure swing adsorption facility; a—contractor's private working area; b—construction sites usually have more than one contractor taking care of specific activities; c—contractors' and WMGI (White Martins Gases Industriais) administrative buildings; d—a pipe shop for a third contractor, or a separate construction area; e—for assembly and preparation; f—for piping spools preparation.

- for each observation, a protocol report shall be filled with the site name, the date of the observation, the name of the safety representative in charge of the task and the invited professional. During the observation process, the observers register on each protocol report field (by site area) at-risk behaviors and unsafe conditions (findings) captured and immediately corrected, which may involve prompt action and/or discussion (e.g., two contractor employees—with contractor's name—without hard hats means two at-risk behaviors while a scaffolding with no tightened wood plates means one unsafe condition). There are also report fields to inform the approximate number of workers (by company, i.e., WMGI's or contractor's employees. This has just statistical purposes, because the company's treatment is the same for employees and contractors) in the area during the observation period. Depending on the site size and the number of tasks performed in the area during observation, a complete observation may take 30–60 min;
- all observation reports for each site during a month are sent to the GSS safety management for data calculation and graphic consolidation into a spreadsheet. With the number of findings (at-risk behaviors and unsafe conditions) observed for each area, a finding index (weight behavior) is calculated multiplying findings per workers observed on a centesimal basis. This index can be understood as the nonconformance status or, in other words, the "stress"[4] level of the site, because unsafe behaviors and conditions happening at the same time in the same area, affecting different workers of different companies, represent a shared factor for safety instability for everyone while it remains. The goal established for this index, for each site, is less than .1;
- on the basis of this information we plot this weight behavior index during each site lifetime, for all companies working there (WMGI and contractors), as a behavior-based "photograph" of the working area. We also indicate incidental events that occurred at the site during the same (Figure 2). Although it is not necessarily conditioned, these plots have frequently brought up an evident link between the weight behavior index increase—at least for one of the working companies at the site—with the occurrence of incidental events, revealing a consistent trend instead of a mere coincidence;
- usually the worst results in terms of behavior-based observation (high weight behavior index) are due to field pipe shop installation and kick off activities, as seen in Figure 2, usually caused by an adaptation by contractors of a new safety work process, and followed by a quick response of field personnel with the observation tools and safety management system by the management team. A construction site is a temporary activity (sometimes as short as two months) with a very dynamic process that involves different tasks (excavation, civil construction, mechanical, pipe, and instrumentation field erection), a variable

[4] Stress shall be understood as a synonym of lack of adaptation to (related to worker–activity integration), or imbalance in safe work conditions, generating errors, which will be observed in at-risk behaviors and unsafe conditions usually present on the site, contributing to contamination of the safety behavior-based status of all workers, as a contributing factor to incident and injury basis.

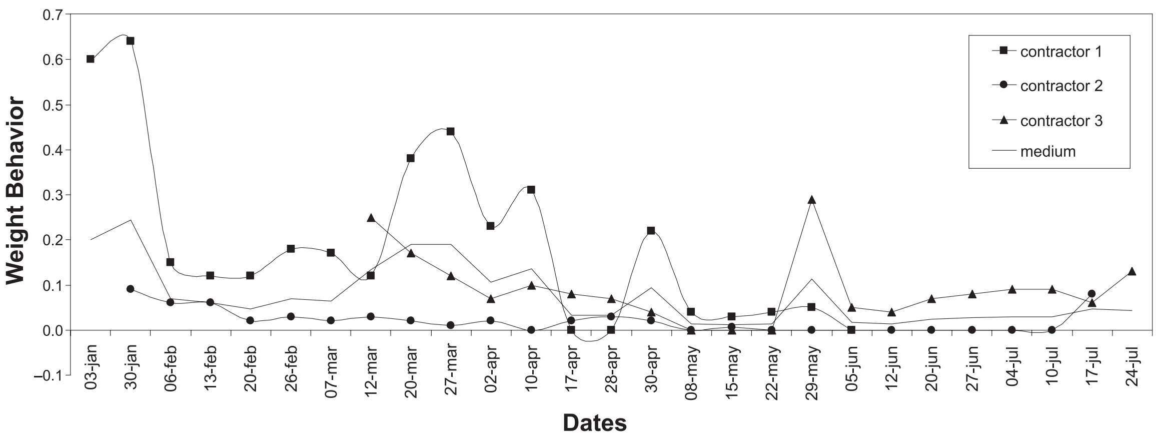

Figure 2. At-risk behaviors and unsafe conditions observation system plot for all contractors, with incident/accident indication, at a construction site. *Notes*. IN—incident, NLWC—non-lost workday cases; incident/accident flags indicate contractors' ownership.

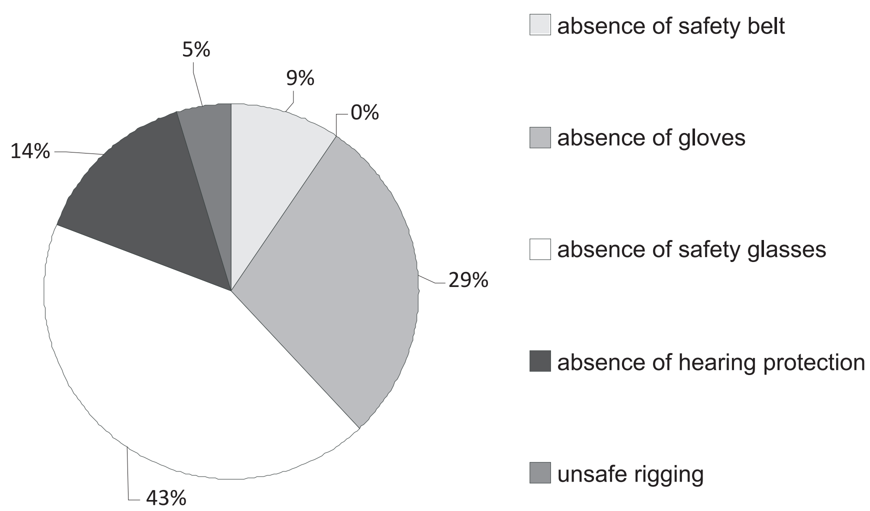

Figure 3. Distribution by type of at-risk behaviors observed at the site areas (%). *Notes*. PPE—personal protective equipment.

number of contractor companies and professionals per contractor at the site, personnel interaction, different schedule pressure, etc., which impact behaviors and the result of the monthly "photograph" obtained from weekly observations, which are also performed by different guests with the field team. These are the most important contributing factors for the observed weight behavior variance in Figure 2 (although most of the time it is within the goal of less than .1 and just capturing only occasional extrapolations), but that is also the most important feedback for field management team to implement the most appropriate action plan to eliminate or mitigate the observed findings to prevent the occurrence of an incident scenario, and in consequence, to achieve our goals (KPIs) [28];

- additional information is also available from this calculation, e.g., a comparison of at-risk behaviors and unsafe conditions for one site or a specific contractor at a construction site, or for different site areas. We can also compare contractors or even site performances, and get the most important types of at-risk behaviors and unsafe conditions that have been more frequently observed in recent weeks or for a long period of time at the site (Figure 3).

The most significant ones are pointed out for the site safety staff for special attention and actuation, as part of an action plan. For all this information, the system provides a picture on a monthly basis and complete accumulated data for an operation profile during the lifetime of the site;

- a monthly report, which represents a specific behavior-based "picture", is generated for each site and, with recommendations of the safety management team for the site safety staff, as an action plan to be followed, to preventively correct issues and provide specific support and training to achieve performance improvement.

3.3. Phase Three: Safety Adherence Observation System (PPI)

Efforts must be directed at reinforcing safety planning and the behavior of the worker's management. Especially regarding construction sites, most contractors are not sophisticated enough to include behavior-based safety directed at their employees as part of their safety systems [29]. The actions of the workplace personnel are the result of those systems and the environment that has been created at the site. In the end, success depends on the ability to communicate expectations and to observe the actions of the management team, and the actions of the site workers.

The search to accomplish corporate KPIs and implement a safety observation system to capture and correct at-risk behaviors and unsafe conditions is fundamental to any workplace safety strategy. However, there are two common characteristics of these implemented processes that have impelled us to introduce a new safety observation system with a different approach, which represents a safety process performance indicator (PPI). The first is related to the negative aspect of pointing out and trying to avoid errors or incidental events and injuries. Their occurrence always involves the team's feeling of failure, usually because of bad news related to safety. Especially regarding incidents and injuries, the average sensation is quite similar to a soccer game, where the best result for our team is just a tie with no goals scored. Any event represents a defeat and makes our mind ask it happened after all the efforts, systems, tools, skills, and procedures we put in place? And frequently we used to answer ourselves with "they were still not good enough"; even considering the aggressive goal we set for our company's safety strategy. The second issue addresses the incapability of these processes to enhance all team efforts to improve safety awareness, teamwork, communication, problem solving, strengthening safety training and learning (of different processes, technologies, procedures, standards, and management systems), and creating a real safety culture. This culture is expressed by the workers' adherence to design and task safety reviews, job safety analysis, site assessments, technical and safety requirements, and operational discipline [30, 31], regardless of the problems with adaptability (temporary contractors and cultural diversity). All these factors may be called an actual invisible effort, reinforcing the team's feeling of frustraton.

Observations can be made at any time with the safety handbook checklists. They are structured to allow any WMGI employee, with any level of knowledge, to oversee workers' safety, observe at-risk behaviors, assess the site's management of safety and the overall safety performance of workers (contractors and employees), conduct contractor administration, and learn about safety requirements [22]. Although these safety observations were initiated on all GSS sites with the introduction of safety handbooks, the third phase started in December 2006, on the basis of similar main criteria for construction sites and GSS factories:

- GSS safety supervision personnel at the sites, i.e., actually the safety technicians and site supervisors shall also conduct the system. They are trained to understand the safety requirements and the observation system methodology to be facilitators and their focal points. In the case of construction sites, the contractor's management shall be present during the observation to guarantee good feedback and understanding;

- the key is the knowledge of what to observe. GSS (factories and construction) handbooks are structured to give the necessary knowledge to the supervision to observe the major activities relevant to ensure safety of construction and fabrication. Observing is an activity that can be done almost anytime, given preparation, planning, and some guidelines;
- to facilitate and standardize this kind of observation, handbook checklists were grouped by subject or interest area; the construction safety handbook has 18 different checklist groups as indicated in Figure 4 for construction. One checklist group shall be filled on each observation. Each checklist item has three possible answers: *YES* for a desirable compliance level on the checked item; *NO* for nonconformance detected for an item; and *NA* for a not applicable item on the activity that is being observed;
- GSS safety supervision personnel shall plan safety adherence observations to be done at least twice a week in such a sequence that all checklist groups can be used as a tool for observers in a shorter period of time; schedule changes may be done on the basis of dangerous activities for a specific occasion;
- all observation checklist groups completed for each site during a month are sent to the GSS safety management for data calculation and graphic consolidation. The safety adherence index is obtained by dividing the total number of *YES* answers by the total of applicable answers (*YES* + *NO*). This index can be understood as the site safety conformance status, i.e., adherence to the safety procedures and requirements previously established, in which all personnel were trained and which they agreed to follow. The goal established for this index is more than .9, as indicated in Figure 4 for an actual construction site. The ones with unsatisfactory adherence levels are pointed out to the site safety staff and management supervision for special attention and actuation, as part of an action plan;
- on the basis of this information, we can display the safety adherence index in the same plot showing the weight behavior index (of the at-risk observation system) during each site lifetime, for all companies working there (WMGI and contractors). These safety adherence results complete the at-risk behavior monthly report, generated for each site, representing a complete behavior-based photograph of the working area, regarding undesirable conditions and behaviors, and a demonstration of the safety compliance level according to our requirements (weight behavior index lower than .1; and the PPI greater than .9), which are our process goals, as seen in Figure 5 for an actual construction site (flags indicated when incidents and accidents took place). The same contributing factors pointed out for the observed weight behavior variance in Figure 2 are applicable

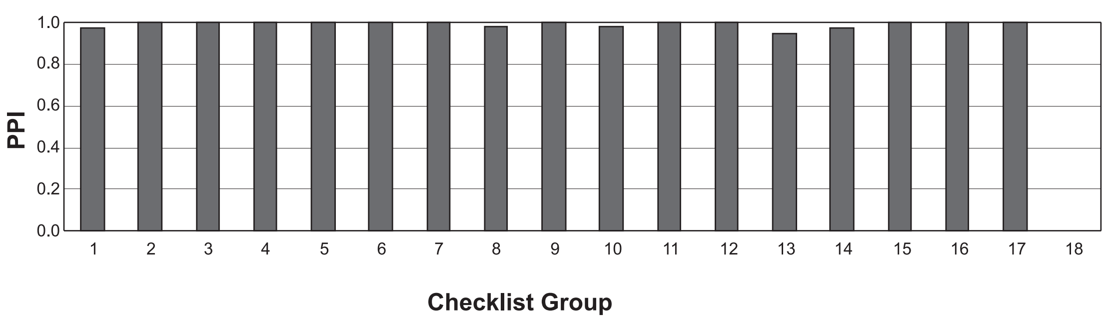

Figure 4. An actual safety adherence index result for each observed checklist group at a construction site. *Notes.* PPI—process performance indicator; 1—signs/awareness, 2—layout/postings, 3—security, 4—PPE (personal protective equipment), 5—barricading areas/access/lock and tag, 6—hazardous and hot work, 7—compressed gas cylinders, 8—electrical safety, 9—fire protection and prevention, 10—elevated work, 11—heavy equipment, 12—rigging, 13—ladders, 14—scaffolding, 15—high pressure/radiography, 16—confined space/fuel storage, 17—respiratory protection, 18—excavation/floor, wall and roof openings.

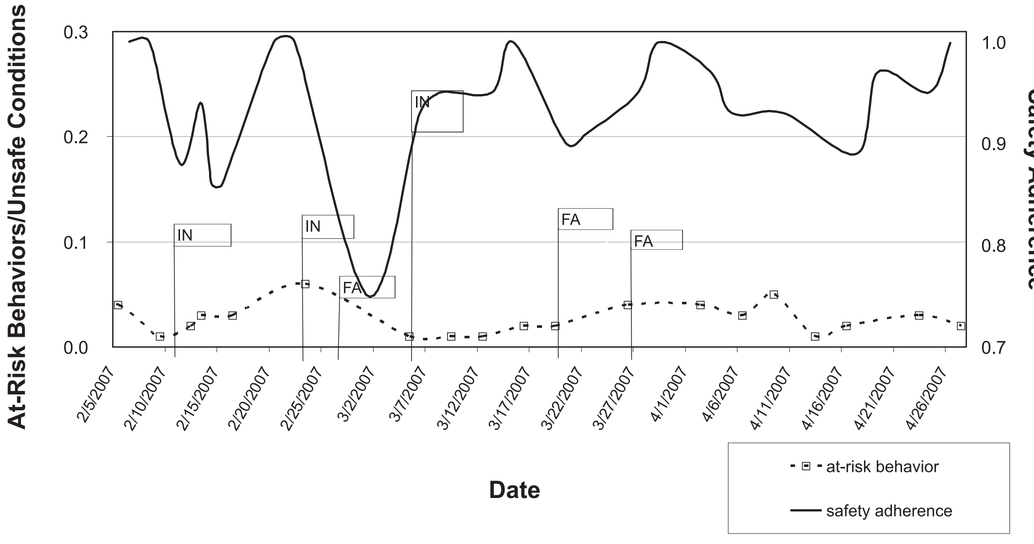

Figure 5. Safety adherence observation system index plotted with the at-risk behavior/unsafe condition observation system index for a construction site. *Notes*. IN—incident, FA—fatal accident.

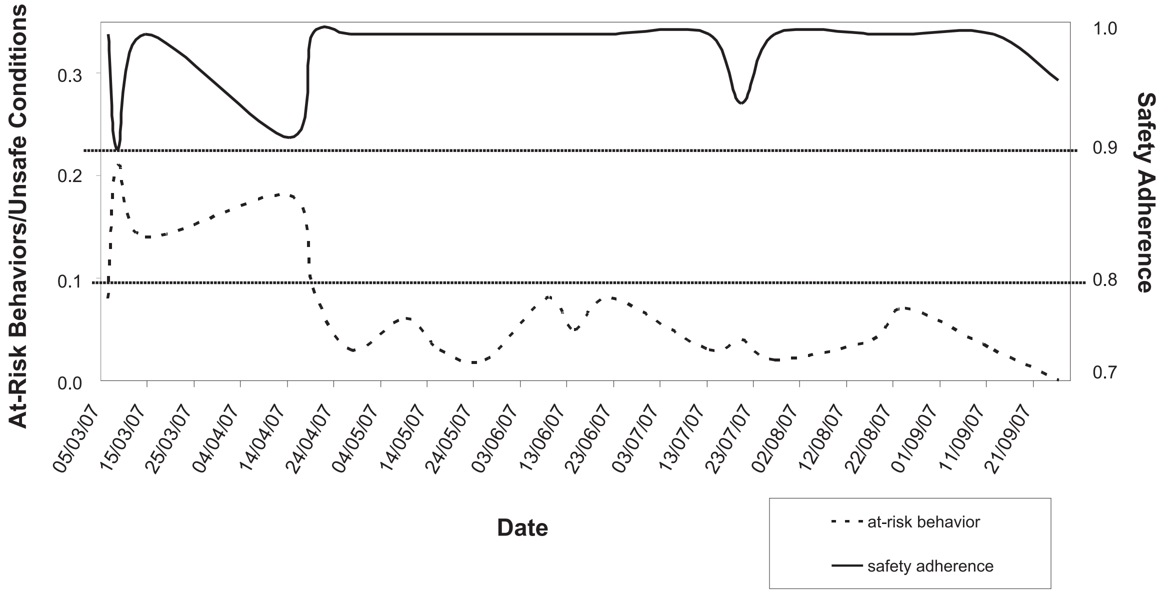

Figure 6. Safety adherence observation system index plotted with the at-risk behavior/unsafe condition observation system index for a different construction site.

here to understand the PPI variance over time of the site work, with the same important feedback;

- although they are not necessarily conditioned, the two curves put together in Figure 5, frequently have brought up quite an evident link between the weight (at-risk) behavior index increase and the safety adherence index decrease (and vice versa), displaying a consistent trend, instead of a mere coincidence, as seen in Figure 6 for another site. Nevertheless, these observation systems do not represent opposite versions or the inversion of each other. In fact, while the first captures objective unsafe actions and potential hazards created at the site, the other one (PPI) intends to verify compliance with procedures, programs, documentation, accountabilities, updated designs, maintenances, permits, investigations, knowledge status, precautions, training evidence, and all such things that can demonstrate a complete safety compliance with the handbook that is supposed to be followed for each observed activity.

4. CONCLUSIONS

All the implemented activities described here have proved to be an efficient safety management tool for the behavior-based monitoring of working areas for construction sites and mechanical industries. Although it still needs to be tested, this process may be applied to any kind of industry. It has demonstrated innovative characteristics such as fully integrated safety observation systems with an easy, quick, and inexpensive to implement process, creating important effective preventive practical results; promoting on-the-job training for all personnel; and improving safety culture and organizational climate for WMGI.

The tool differs from the most common field safety management processes that used to be based on task reviews, specific job audits, observations per activity, or punishment/reward assessments. This safety management tool also takes into account all critical safety factors that usually affect an implementation of a safety program [2, 18], like the presence of clear and realistic goals, good lines of communication between management and workforce, clear roles and responsibilities, adequate resource allocation, effective management support, continuous program evaluation with personnel's participation for motivation and adherence, development of personal competency and teamwork. It also establishes positive group norms to achieve positive personal attitude toward safety, appropriate supervision, and safety education and training to improve workers' knowledge and skills of safety.

Observation and feedback can powerfully affect how the worker performs. By having a knowledgeable observer watching a working environment, safe and at-risk behaviors, and unsafe conditions and process compliance can be measured. Immediate feedback provided by the observer and the management team can point out work safely done. The observer can coach improvements to replace at-risk work behaviors with safer methods and share safety and technical skills with other invited professionals. This process must be accomplished with the site's supervisors hoping that they will lead the discussion. A well-designed system brings positive coaching interaction between the worker and the observer. Effective feedback is immediate, specific, and constructive, and delivered by a creditable co-worker. Usually the worker has an immediate opportunity to try the recommended changes by resuming work using the new skills. Sometimes behaviors are hard to break. Repeated coaching interactions are needed to reinforce behavior changes. Heinrich, Petersen, and Roos showed that this approach would change even well-entrenched habits [3]. The process changes how people interact at work and safety becomes an accepted topic of conversation. Workers become more comfortable alerting each other of hazards. Knowledge about safety is shared as the observations detect improvements and bring them into the coaching process. Depending on the industry profile, there is emphasis on managing the contractor's management systems. This coaching and interaction allow the company's management team to determine the extent and value the workers (employees and contractors) give to safety. Documentation of this activity is a critical process that collects and distributes data on observations, follows up safety performance, and communicates safety evolution to all organizational levels.

Finally, this safety management tool, with all systems associated, will certainly provide as a natural tendency a new company core competence [32]. This process is developed as a fundamental issue to improve strategic changes and competitive advantages within the industry environment, and to create value for customers, with a probable new market entry for safety services [33].

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