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Criticalities on Highway Maintenance Yards: Some Suggestions to Improve the Effectiveness of OS&H Supervision/Inspection Activities

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Research work results on Occupational Safety and Health -OS&H- aspects of highway maintenance yards in normal operative conditions and special situations - typically potential interferences from heavy traffic - stressed the diversification of yards typologies and criticalities.
The European Directive 92/57/EEC on the implementation of minimum Safety and Health requirements at temporary or mobile construction sites concentrates on the improvement of Risk Assessment and Management from the very first steps of the design, and introduces coordinators charged of a safe project preparation and of the execution phase supervising. In particular, in the case of highway maintenance yards, the Coordinator for safety and health matters at the project execution stage should manage both routine situations, and situations requiring high expertise and capacity of judgment. In such complex scenarios, Safety inspection activities become a demanding task also in terms of time and resources for both the Company and the National Inspectorate supervisors.
The paper discusses an original approach for the optimization of supervision / inspection activities, based on the appropriate use of Fellow Supervisors to support the Coordinator in the routine activities, with the added benefit of an increased presence of "safety people" at the yard. The setup of an appropriate data gathering, recording and mining system, organized in interlinked cards in logical sequence, contributes to the efficiency and thoroughness of the work of the both the Coordinator and the Fellow Supervisors. The results of ex post tests on a real case –input data provided by the Prosecutor Office which proposed the study- can be considered significant.

1. Foreword

Two main topics may condition the safety of both workers and third parties, in general and more so in the case of particularly risky and complex activities such as the ones here discussed:

a) the adoption of a Prevention through Design –PtD- approach, which should consider both Safe Work Organization and the Maximum Safety Technologically Achievable criteria, in coherence with the provisions of law (89/391 EEC Directive, enforced in Italy by D.Lgs.81/08), where we can read: "Art.6. General Obligations on employers, c.2. The employer shall implement the measures referred to in the first subparagraph of paragraph 1 (necessary for the safety and health protection of workers, including prevention of occupational risks and provision of information and training, as well as provision of the necessary organization and means) on the basis of the following general principles of prevention: … (e) adapting to technical progress". The 92/57/EEC Directive special for temporary or mobile construction sites, also included in the Italian D.Lgs.81/08, reiterates and details these concepts, and sets this task to the 'Coordinator for safety and health matters at the project preparations stage'. These criteria should then

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be applied both to operations developed in the maintenance yard, and, from a more general point of view, to the context in which the maintenance site is located.

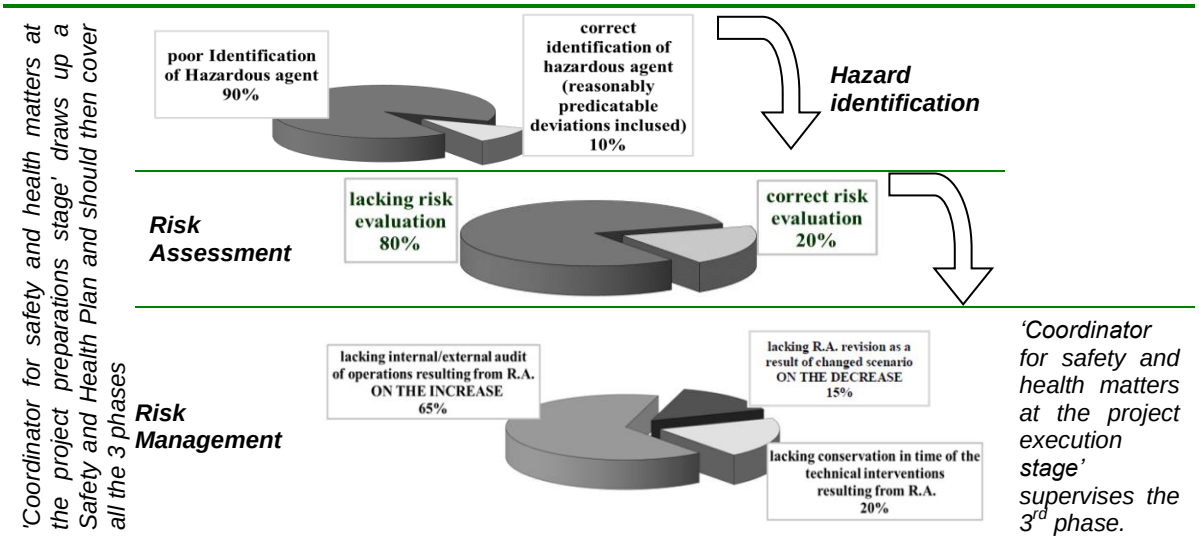
b) the minimized Risk level achieved for the system should be preserved and improved along the time, nowadays in accordance to quality principia (e.g. according to OHSAS 18000). The aforementioned 92/57/EEC Directive sets this task to the 'Coordinator for safety and health matters at the project execution stage', as detailed in Table 1, the main reference for his activity being the Safety and Health Plan (drawn by the 'Coordinator for safety and health matters at the project preparations stage').

Table 1: Tasks of Coordinator for safety and health matters at the project execution stage - 92/57/EEC Directive, Article 6

Project execution stage: duties of coordinators
The coordinator(s) for safety and health matters during the project execution stage appointed in accordance with Article 3 (1) shall: *(a) coordinate implementation of the general principles of prevention and safety:* *- when technical and/or organizational aspects are being decided, in order to plan the various items or stages of work which are to take place simultaneously or in succession,* *- when estimating the period required for completing such work or work stages;* *(b) coordinate implementation of the relevant provisions in order to ensure that employers and, if necessary for the protection of workers, self-employed persons:* *- apply the principles referred to in Article 8 in a consistent manner,* *- where required, follow the safety and health plan referred to in Article 5 (b);* *(c) make, or cause to be made, any adjustments required to the safety and health plan referred to in Article 5 (b) and the file referred to in Article 5 (c) to take account of the progress of the work and any changes which have occurred;* *(d) organize cooperation between employers, including successive employers on the same site, coordination of their activities with a view to protecting workers and preventing accidents and occupational health hazards and reciprocal information as provided for in Article 6 (4) of Directive 89/391/EEC, ensuring that self-employed persons are brought into this process where necessary;* *(e) coordinate arrangements to check that the working procedures are being implemented correctly;* *(f) take the steps necessary to ensure that only authorized person are allowed onto the construction site.*

Taken into account the typical situation of a large number of construction activities summarized in Table 2 (Patrucco, 2008), the 'Coordinator for safety and health matters at the project execution stage' should devote special care in the supervising of the 3rd phase (Risk Management). The linked pie charts summarize the errors in the Risk Assessment and Management process causing accidents (as resulting from Prosecutor investigations).

Table 2: Safety experts and their demanding tasks



In particular, he should evaluate the Safety documentation drawn by the employers and, if necessary, ask for amendments (the responsibility of the employers remains in any case unaffected, as provided for in 89/391/EEC Directive).

This also is somehow frustrating, since, as shown in Figure 1, only in a limited number of cases the situation results directly acceptable.

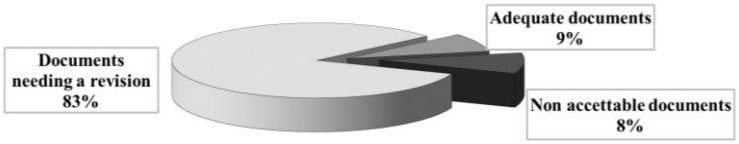


Figure 1: Results from a statistical analysis on the congruence between the Safety and Health Plan and the Safety documentation drawn by the employers, in a number of real cases.

2. The original approach to system organization, proposed to support the activity of the 'Coordinator for safety and health matters at the project execution stage'

In the case of maintenance/improvement interventions on highway stretches, the 'Coordinator for safety and health matters at the project execution stage' should supervise and manage the OS&H during the yard activities, especially in the critical phases, referring to the Health and Safety plan.
In this complex scenario, the task of the Coordinator can become very challenging, since:

- ✓ the typologies of yards are very diversified (Borchiellini et al., 2015); moreover, very different activities are often necessary in the same yard;
- ✓ the risk attributable to Hazard Factors typically affecting the linear temporary or mobile construction sites are worsened by factors which can directly or indirectly influence and condition the safety of both workers and third parties. In fact, limited spaces, high power complex and special equipment, haste to complete the work, traffic vs yard interferences possibly involving heavy dangerous goods traffic often increase the seriousness of the consequences of any possible deviation;
- ✓ an effective approach to the possible criticalities entails different levels of expertise: a) highly qualified, to perceive and manage problems of difficult identification, involving accurate and critical appraisal of the general yard layout and organization, safety solutions for normal conditions and emergencies, cooperation between employers if necessary, equipment selection and its safety characteristics, crew composition and adequacy, etc., b) elementary knowledge of the more patent lacks in organization, actual crew composition and adequacy, equipment faults or misuse, and workers misconduct. It should be emphasized that, apart their intrinsic importance, the evident criticalities can be symptomatic of not immediately identifiable OS&H problems;
- ✓ safety inspections can then result particularly onerous in terms of resources an time involved: practical experience confirms that, whilst at depth inspections thoroughly covering the critical operations can be sparse, the elementary level inspections should be frequent, to promote the attention to OS&H of personnel with various qualifications working in the yard.

The original approach here proposed to increase the safety of workers and third parties involved in the maintenance/improvement of highway stretches focuses on the optimization of the work of the 'Coordinator for safety and health matters at the project execution stage' (from here 'Expert Evaluator'), and of his staff (from here 'Fellow Evaluators'), and covers the Safety analysis and the periodic audits and inspections phases.
According to the suggested approach the Expert Evaluator:

- ✓ carries out firsthand the in-depth preliminary analysis, and the on-site inspections in case of special phases of recognized criticality as resulting from the time schedule, and organizes, coordinates and discusses the activities of the Fellow Evaluators, who access the yard frequently;
- ✓ makes available to the Fellow Evaluators adequate data collection forms and evaluation indexes for "weighing" situations or behaviors complying / not complying with the basic OS&H regulations and good practices, to support their work. At the purpose we evolved a Safety Index from what suggested by Laitinen H. et al (1998, 2002), expressed by Eq(1):

$$Safety\ Index = \frac{\#\ observed\ compliances}{\#\ observed\ compliances\ +\ \#\ observed\ NON\ compliances} * 100 \quad (1)$$

  The Safety Index can be directly calculated as a weighted average of the results of all the observations made in the yard in relation to the different deviation scenarios under observation, or, as we also tested, subject to corrective coefficients ascribed to the various deviation scenarios, as a function of the statistical frequency and / or the severity of the consequences;
- ✓ completes the critical analysis of all the gathered information: the final result is a formalized, rigorous and objective rating on the OS&H yard situation, precious for the adoption of possible improvements, and, in the case, to support the client on measures against the employers.

Figure 2 summarizes the logical framework of the approach. A side benefit of the proposed approach is the possibility to implement the data collection forms in a computer assisted system; the Authors are developing a software in Visual Basic®, up to now available in alpha version.

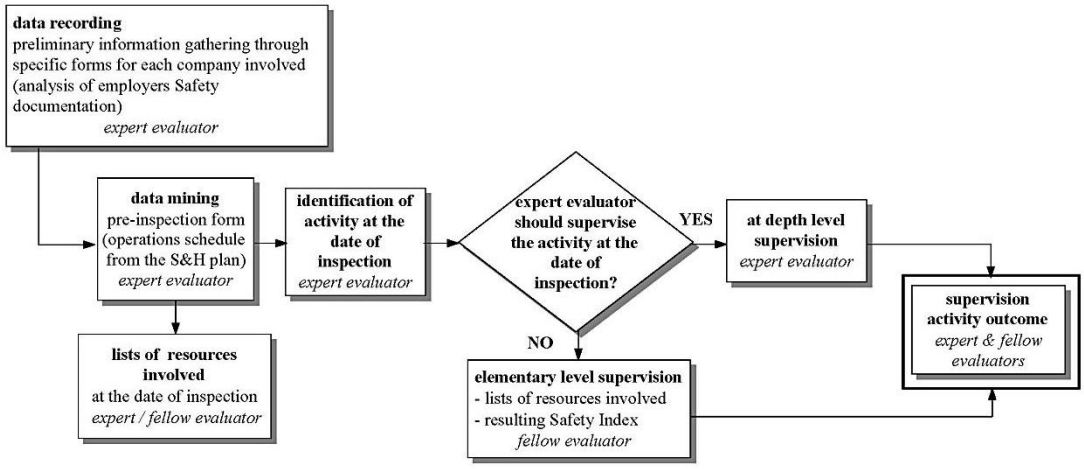


Figure 2: Flow chart summarizing the optimized safety analysis & inspection process.

3. The results of the proposed approach in a ex post fatal accident test

As stated, the Prosecutor Office which proposed the research provided detailed technical information on a number of fatal accidents occurred during highway maintenance operations. Here we discuss the results of ex post tests of the originally developed safety analysis and inspection process, as applied to the case of a run over occurred in 2006 in a highway stretch in Western Italy.

Table 3 summarizes the basic data and results of the accident, analyzed by means of the Computer-aided Cause Consequence for Prevention - CCCP technique (Luzzi et al., 2015).

Figures 3, 4 and 5 exemplify the possible results of the suggested approach, summarized with reference respectively to the preliminary evaluation by the Expert Evaluator, routine activity of the Fellow Evaluators, and overall assessment on the highway maintenance yard Safety expressed by the Expert Evaluator.

Table 3: Results of the CCCP technique applied to the considered 2006 accident

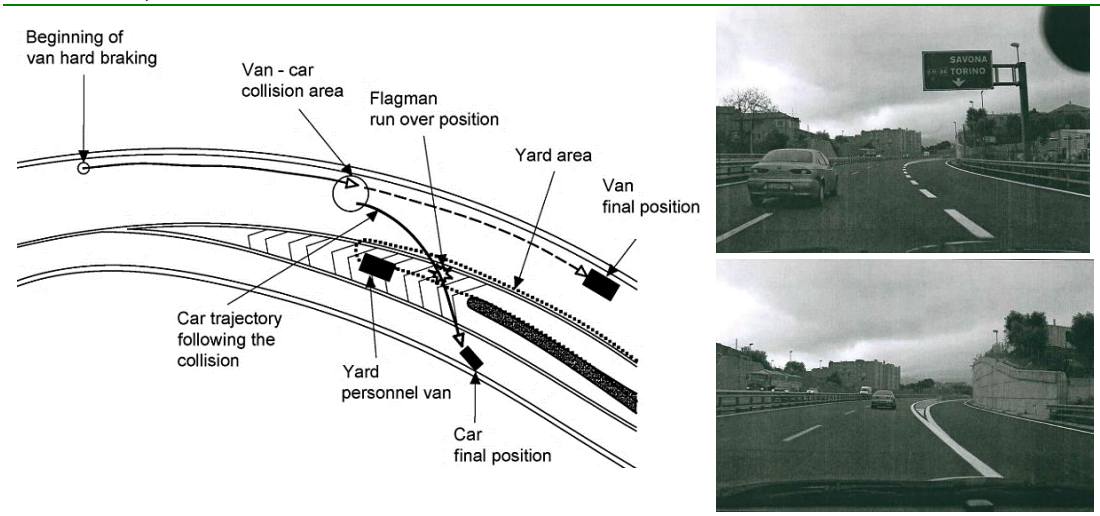
The event occurred in March 2006, during a signage cleaning activity in a stretch of a Western Italy highway, near a junction (see sketch (below), and shots of the area (right). At 3 AM, a worker signalling to the users the lines narrowing was run over by a car of regular traffic, which lost control due to the impact of an oncoming van traveling at speed not compatible with the maximum permissible in proximity of the working area (for Italian reference to the special situation see also D.I. 4 March 2013).


Table 3: Results of the CCCP technique applied to the considered 2006 accident

ACTIVITY SECTOR F42 Construction – Highways, etc. CONSEQUENCE → 1 workers involved				NOTES: data resulting from Prosecutor Investigation	
A vehicle, hit by a van, loses control and runs over the flagman in a highway maintenance yard, set up to clean the highway signage. The event occurred overnight.					
	Accident causes chain			Possible corrective measures	
	1	1 fatality		n.a.	IX
	2	struck by a vehicle out of control		see II	VIII
	3	loss of control of the involved vehide due to rear-ending		n.a.	VII
	4	poor working area signaling		see II	VI
	5	unsafe signaling operation		see IV&III	V
	RM	poor risk management		resulting from II, III & IV	RM
		6	inadequate signage and lacks of signaling and protection systems of working area	work organization (safety lanes, traffic detour, etc.) with special reference to tasks assignment, and supervision IV	
		7	improper worker IFT and working procedure	focused IFT and traffic vs yard interference analysis III	
		8	lacking work organization, improper task assigned to the worker involved and poor supervision	temporary collective protection systems (e.g. barriers, Truck Mounted Attenuators, etc.) II	
	9	poor Risk Assessment and Management, in particular entrusting unsuitable tasks to workers		adoption of Prevention through Design and Quality management approaches special for the yard	I

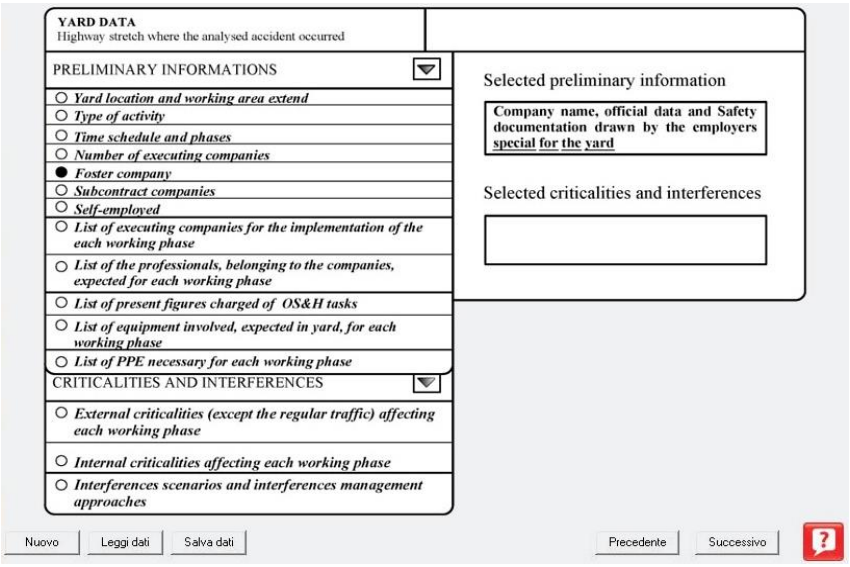


Figure 3: Minimum information to collect previously to the beginning of yard activities.

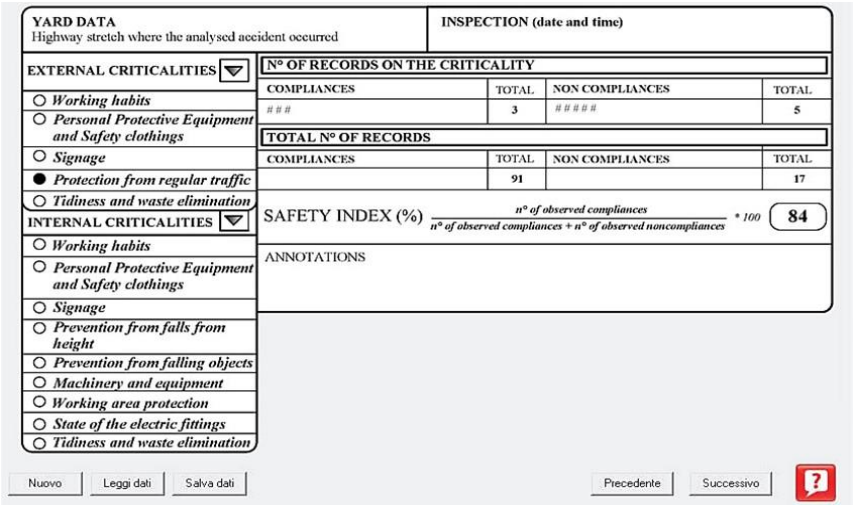
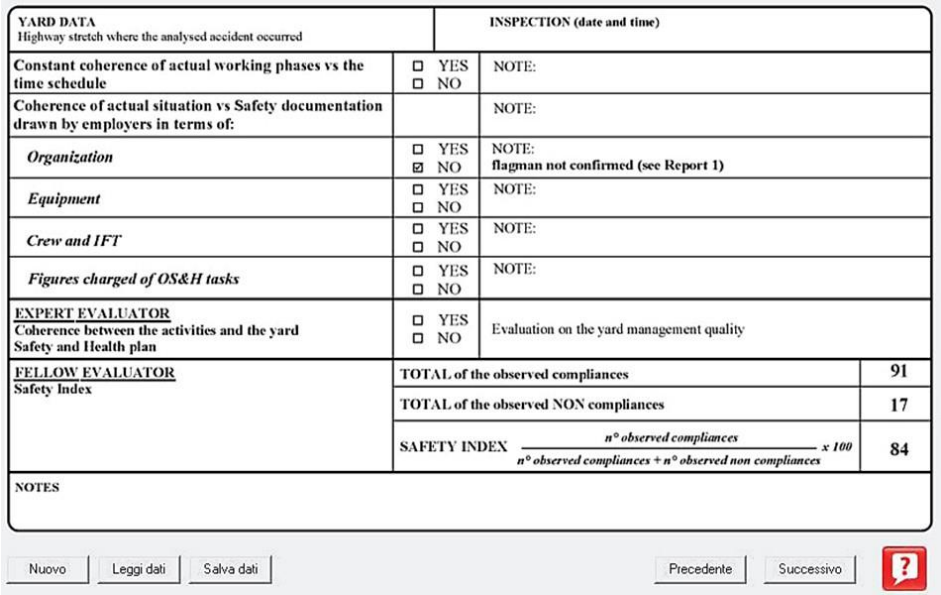


Figure 4: Example of a Safety Index form filled by a Fellow Evaluator.



YARD DATA Highway stretch where the analysed accident occurred		INSPECTION (date and time)
Constant coherence of actual working phases vs the time schedule	☐ YES ☐ NO	NOTE:
Coherence of actual situation vs Safety documentation drawn by employers in terms of:		NOTE:
Organization	☐ YES ☑ NO	NOTE: **flagman not confirmed (see Report 1)**
Equipment	☐ YES ☐ NO	NOTE:
Crew and IFT	☐ YES ☐ NO	NOTE:
Figures charged of OS&H tasks	☐ YES ☐ NO	NOTE:
EXPERT EVALUATOR **Coherence between the activities and the yard Safety and Health plan**	☐ YES ☐ NO	Evaluation on the yard management quality
FELLOW EVALUATOR **Safety Index**	**TOTAL of the observed compliances**	**91**
	TOTAL of the observed NON compliances	**17**
	SAFETY INDEX $\frac{n° \text{ observed compliances}}{n° \text{ observed compliances} + n° \text{ observed non compliances}} \times 100$	**84**
NOTES		

Nuovo | Leggi dati | Salva dati | Precedente | Successivo

Figure 5: Compendium form filled by the Expert Evaluator, containing his direct observations, and the results of the activities of the Fellow Evaluators.

4. Conclusion

The peculiarities of the highway maintenance/improvement yards impose special Risk Assessment and Management, and stress the need of systematic and thorough Safety inspections.
The research work - proposed by a Prosecutor Office- made possible the development of an original approach for Safety analysis, periodic audits and inspections, aimed to improve the efficiency of the work of the 'Coordinator for safety and health matters at the project execution stage', and of his staff of Fellow Evaluators. The approach can be of some help also for the National Inspectorate supervisors and their stuff.
Thanks to a special organization of the Safety data management system, based on forms for the systematic and thorough recording of the results of the evaluation and inspection activities, and to the introduction of Safety Indexes, the technique can lead to a formalized, rigorous and objective rating on the OS&H yard situation. The approach results precious for an effective and timely identification of both clear and embedded safety criticalities for workers and third parties, and for the adoption of possible improvements of OS&H.
Finally, the frequent and long-lasting systematic presence of Fellow Evaluators at the yard can contribute to a substantial improvement, in terms of increased attention to OS&H problems and responsibilities, continuous cooperation on the safety aspects, and in more general terms wide spreading of the Culture of Safety.
Even if in situ tests of the suggested approach and the engineering of the software are still undergoing enhancement, the improvement of the general attention to the OS&H issues, in some highway maintenance yards, as recorded by experts of the National Inspectorate supervisors, appear encouraging.

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