POLITECNICO
MILANO 1863

SCUOLA DI INGEGNERIA INDUSTRIALE
E DELL'INFORMAZIONE

EXECUTIVE SUMMARY OF THE THESIS

Checklists and Behavioral Measurements in Process Industry

MASTER'S THESIS IN PREVENTION AND SAFETY ENGINEERING IN THE PROCESS INDUSTRY

AUTHOR: STEFANO CAMPANALE

ADVISOR: FABIO TOSOLIN

ACADEMIC YEAR: 2021-2022

1. Purpose of the study

Checklists are an essential tool in the field of safety. After a significant study developed in the field of aeronautics and medicine, today the applications of checklists for safety purposes are widely used in practically every working environment, from construction sites to process industries. However, the wide diffusion of the tool is not matched by an equally large number of studies that describe the characteristics that a checklist needs to have to effectively achieve the desired results. In addition, it is even important to mention that no explicit and strictly functional classification, that compares the use and effectiveness of the different types of checklists, has been done.

2. The checklist usefulness and types

Today we are aware that, even if we are provided with the same safety conditions or tools, there are often large differences in accident outcomes. This suggests that the main differences may be due to the only safety tool that cannot be purchased but must be developed and maintained through managerial actions within the production context, and this is behavior. Behavior that is, in many cases, the object of study in checklists.

Behavior is the main element measured when adopting a checklist, individuals can determine if a specific behavior has occurred or not in a determinate situation, more specifically if a safe behavior has been observed throughout an activity.

Traditionally, behavior is the object of interest when a checklist is used to evocate a series of actions in a sequence, avoiding neglecting some of these. Further, behavior is indirectly the object of interest even when checklists are used to verify the presence or the absence of a structural condition or device, too. When checking the presence of a condition, indeed, we are considering the presence or the absence of a result, being such presence the effect of previous behavior of someone.

Such considerations leaded to a debate in the field of Behavior Analysis, regarding the relative effectiveness to build checklists based on results rather than on the behaviors which cause them.

Therefore, through this study we tried to identify a criterion for classifying the different types of checklists. Performing such classification, we hope

to be able to discriminate among checklists devoted to start behaviors, devoted to correct a bad condition or mistake, or devoted to measure and change the further emission of safety behavior. The third capability refers to a relatively unknown use of the checklist: providing the basis for an intervention to improve or eliminate in the future the risk condition that has been detected, diminishing or even eliminating the reason to use the checklist itself.

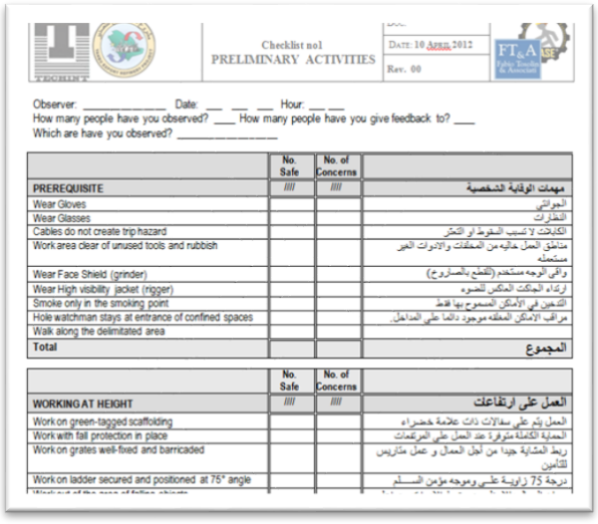
3. Rationale of a scientific point of view on checklist use

The research and the functional classification have shown that the checklists most suited to be used, not only *reactively* (i.e. to intervene following the discovery of a non-compliance), but also *proactively* (i.e. to improve on the occasion of further repetitions of the behaviors of interest), are the ones used and developed in the so-called Behavior Based Safety (BBS) processes.
A peculiar feature of this kind of checklist is the ability to modify the behavior in future occurrences, through the identification of the causes of inadequate performance (Functional Analysis) and the use of immediate and frequent positive feedback and positive reinforcement plus a small percentage of corrective feedback, instead of punishing, sanctioning, teaching or explaining. Data from scientific research show that it is possible to achieve such results only by focusing on a checklist of safe behaviors, rather than focusing on risk conditions of a working environment, which are instead the subject of more traditional checklists.
There is a massive difference between the checklists that are based on measurements and observations in relation to non-compliance behaviors and the ones focusing on the occurrences of safe behavior. When we are asked to observe the behaviors that are not in compliance, we consequentially put in place a sequence of corrective actions, affecting and slowing down the motivation of the person. For such reason, it is important to specify that a checklist that focuses on the observation and measurements of safe behaviors, rather than the unsafe ones, is followed by positive feedback, that increases the future occurrence of that behavior.
In order to analyze the various methods and fields in which a checklist can be implemented, they have to be catalogued according to their characteristics and specifically according to their function (i.e. what will be achieved with the adoption of such specific checklist, depending of the context). According to the aim of analyzing only scientific data about the efficiency and effectiveness of checklists, the measurement scale taken in account have been mainly the parametric ones, limiting the examination of the others (i.e. nominal or quantum scales and ordinal ones).
Examination of reports, studies and research on the subject has revealed an extensive and ancient use of checklists in terms of "**Antecedents**", verbal stimulations provided to the workers in order to evoke **behaviors**, such as safety actions to be taken following the reading of each item on the list. Checklists are therefore used as *reminders* for the correct and complete execution of a series of actions in sequence, such as those required to start an aircraft or carry out preventive maintenance on a piece of machinery, or to perform the ritual for individual protection at the entrance to a dangerous department in a chemical plant.
It was also possible to find a second type of use of checklists in function of "**Antecedents**" in order not to evoke sequences of actions to be carried out, but to determine states and conditions necessary for the start or continuation of activities. With the adoption of these checklists, through the discovery of conditions, **results** that are present or absent, it is possible to determine the continuation or interruption of the activities. However, alternatively, you can adopt a series of corrective actions after a specific activity took place, through the examination of the items on the specific checklist.
Finally, a third method of adoption for checklists was analyzed and introduced 15 years ago also in the Italian industries. This modality has made possible to add to the traditional purposes of verification and reminder of the checklists in occupational safety a further and much more sophisticated purpose. That is the modification of the future occurrences of behaviors, something that was not taken account in the two previous traditional types of checklists that have been presented.
A detailed analysis showed how this checklist model and its outcomes, although almost unknown in the literature relating to checklists, as well as being documented in hundreds of experimental researches and published outcomes

of applications of the method, is characterized by the fact that it allows: (a) to perform quantitative, objective measures of behaviors, (b) to perform contextually a functional analysis of the causes of behaviors underlying safety outcomes, (c) to obtain daily and trend data on safety as well as status photos, and (d) determine the function and effectiveness of provided feedback to the workers. One of the most important elements of this topology of checklist are the use and effect of positive consequences that are delivered to workers in form of feedback, tokens and so on. So, the checklist shifts from an instrument to be aware of unsafe behaviors/results to an instrument to achieve further, more reliable behaviors/results. A promising tool for improving safety much more than has been the case so far.

4. Figures

Figure 1: Example of BBS Checklist



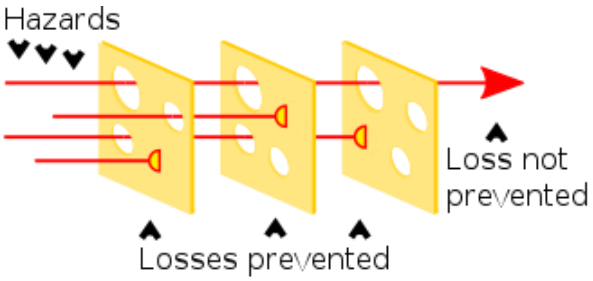
Checklist no1
PRELIMINARY ACTIVITIES
Date: 10 Agosto 2012
Rev. 00

Observer: _____ Date: __ __ __ Hour: __ __
How many people have you observed? ___ How many people have you give feedback to? ___
Which are have you observed? _____

	No. Safe	No. of Concerns	
PREREQUISITE	////	////	مهمات الوقاية الشخصية
Wear Gloves			القفازات
Wear Glasses			النظارات
Cables do not create trip hazard			الكابلات لا تسبب السقوط أو التعثر
Work area clear of unused tools and rubbish			مناطق العمل خاليه من المعدات والأدوات الغير مستعمله
Wear Face Shield (grinder)			واقي الوجه مستخدم (للقطع بالصاروخ)
Wear High visibility jacket (rigger)			ارتداء الجاكت المكشف للضوء
Smoke only in the smoking point			التدخين في الأماكن المسموح بها فقط
Hole watchman stays at entrance of confined spaces			مراقب الأماكن المغلقه موجود دائما على المداخل
Walk along the delimitated area			
Total			المجموع

	No. Safe	No. of Concerns	
WORKING AT HEIGHT	////	////	العمل على ارتفاعات
Work on green-tagged scaffolding			العمل يتم على سقالات ذات علامة خضراء
Work with fall protection in place			الحماية الكاملة متوفرة عند العمل على المرتفعات
Work on grates well-fixed and barricaded			ربط المشابة جيدا من أجل العمال و عمل متاريس للتأمين
Work on ladder secured and positioned at 75° angle			درجة 75 زاوية على وموجه مؤمن السلم

Figure 2: Swiss Cheese Reason



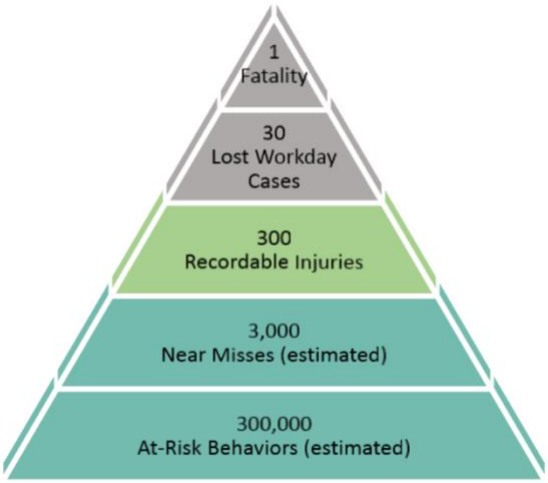


Figure 3: HW Heinrich Model

Figure 4: Positive Reinforcement Graphic

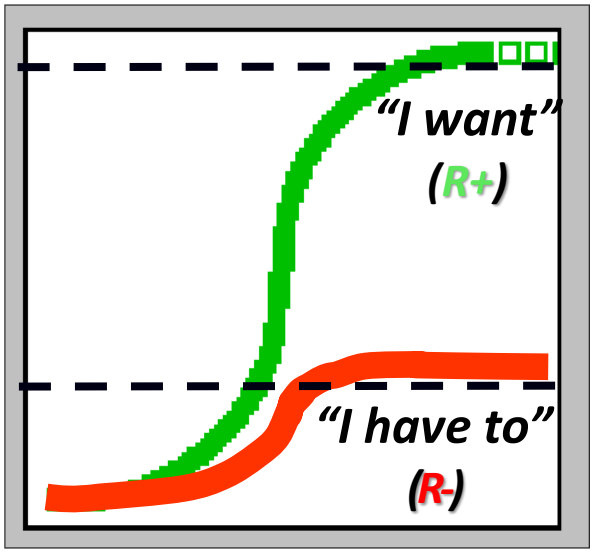
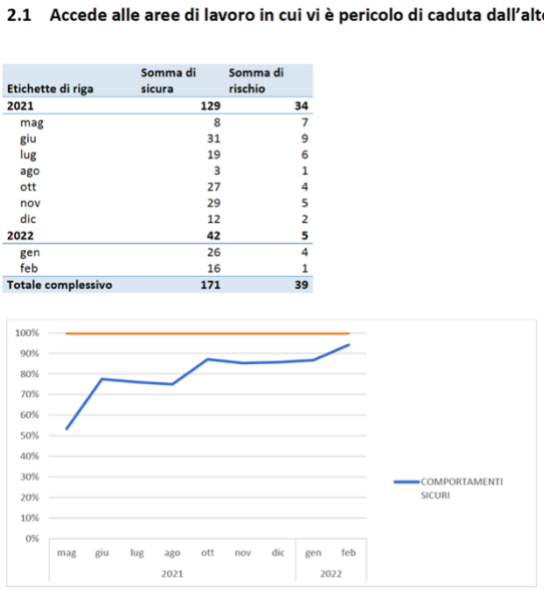


Figure 5: Result of BBS Protocol



2.1 Accede alle aree di lavoro in cui vi è pericolo di caduta dall'alto

Etichette di riga	Somma di sicura	Somma di rischio
2021	129	34
mag	8	7
giu	31	9
lug	19	6
ago	3	1
ott	27	4
nov	29	5
dic	12	2
2022	42	5
gen	26	4
feb	16	1
Totale complessivo	171	39

5. Conclusions

It can be argued that through the adoption of specific rules for the construction of such specific checklists, it is possible to transform traditional checklists into tools that *motivate* people towards the achievement of specific outcomes. The use of checklists to allow the removal of barriers and the delivery of consequent stimuli (feedback, tokens...), has shown to enhance the frequency, duration, latency and intensity of safe behaviors. This guarantees a much higher degree of safety and has a positive effect on motivation, stress levels and the development of a safety culture and values. Being *stress* determined by the adoption of punishment, penalty, extinction and negative reinforcement procedures, being *culture* the coherence between consequences provided by all the managers and workers to a behaver and being *values* verbal statements prescribing the behavior to be adopted under actual circumstances. For these reasons, the integration of this method of construction and use of checklists appears to be recommendable at least in the most critical cases. Even in absence of any other safety devices, instruments or conditions.

So, checklists seems to be promising tools to improve safety much more than has happened so far.

6. Bibliography

Carrara, Laura. "Metodi per la sicurezza industriale che considerano il fattore umano: ambiti di applicazione e analisi comparativa di efficacia." (2011).

Catino, M. "Il caso concordia: alcune riflessioni su un incidente." *Emergency Care Journal* 8.1 (2012).

Catino, M. "Incidenti organizzativi nel trasporto ferroviario." *Ricerche di* (2005).

Daniels, Aubrey C., and James E. Daniels. "Performance management: Changing behavior that drives organizational effectiveness." (2004).

Gawande, Atul, and Duccio Sacchi. *Checklist: come fare andare meglio le cose*. Einaudi, 2011.

James T. Reason, Human error, Cambridge University Press, 1991

Timothy Ludwig, WS Align for the front line, 2022

Tosolin F, Bacchetta AP. Scienza & Sicurezza sul lavoro: costruire comportamenti per ottenere risultati. Milano, A.A.R.B.A., 2008. Traduzione italiana di: Terry E. McSween, "The Values-BasedSafetyProcess", 2003

Figure 1: Mde by Mr Fabio Tosolin

Figure 2: https://www.federchimica.it/docs/default-source/16a-conferenza nazionale-responsible-care/5-maria-grazia-gnoni-universit%C3%A0-del-salento.pdf?sfvrsn=3f4b7e93_2

Figure 3: Canfora, Carmen, and Angelika Ottmann. "Of ostriches, pyramids, and Swiss cheese: Risks in safety-critical translations." *Translation Spaces* 7.2 (2018)

Figure 4: Sala Catteneo, Carlo and Andrea Torretta. "Ricerca sperimentale sull'applicazione

del protocollo B-BS ad una realtà industriale italiana." (2010)

Figure 5: Ambrogi Marco, Presentazione sulla BBS nei cantieri,2022

7. Acknowleggements

I thank Professor Tosolin, Doctor Gatti and all the staff of AARBA, Mrs Carla and Mr Guglielmo, for giving me both the opportunity to collaborate with them for the thesis, and for letting me know and discover the world of BBS and behavioral science.
I thank all my friends and comrades who have supported me in this difficult but rewarding journey and for all the beautiful moments spent together, both at the university and outside.
But above all, I thank my family who supported me, endured, supported, and gave me the opportunity to undertake this path. Special thanks go to my father and my grandfather, who would have loved to be there right now, but unfortunately it wasn't possible.