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Quantitative OHS evaluation: RATE procedure compared with traditional reliability methodologies

Keywords

RATE, SME, OHS

Abstract

The most careful and consolidated risk analysis methods, as FTA, ETA, FMEA/FMECA, focus attention on system reliability. But, looking at OHS, a deep analysis on European data on accidents at work and on work environment in general, shows how reliability is only one aspect of safety problem. These methods then are hardly adaptable when the main aim is to obtain a quantitative assessment of risk for workers; besides, other methodologies are nearest to OHS but give only qualitative results like HAZOP, or base their analysis on not-dimensional values, fixed by analyst on personal experiences, like methods proposed by UNI EN 1050, by standard MIL-STD-882c and by AISS. RATE is proposed as a new quantitative methodology for OHS, particularly dedicated to SMEs considered as the most interesting from these aspect. The paper compares hypothesis and procedures which traditional quantitative methodologies and RATE are based on, to give evidence at the main approach aspects that have to be modified in order to move from reliability to OHS.

1. Reliability and OHS

The most careful and consolidated risk analysis methods, as FTA, ETA, FMEA/FMECA, focus attention on system reliability.

It can be told they're affected from the historically developed industrial sectors, as nuclear or chemical; that is to say, sectors where fault consequences are the most important because of the effects on wide scale they can produce. So we can say that the main target of these methods is to protect a great number of potential victims from "catastrophic" events that could be generated by system faults.

Then, the association reliability-safety deriving from this point of view, appears due to the fact that, in this kind of factories, risks which workers are subjected to, while doing their ordinary duties, are secondary if compared to the consequences of "not-reliability". Despite the importance of these industrial sectors and of the technological related risks, it must be not forgotten that it's essential to focus attention even on other sectors that are subjected to risks that are less serious but more frequent and often linked to causes different from faults.

Looking at data on accidents at work, collected from EUROSTAT or national agencies following ESAW (European Statistics on Accidents at Work) methodology, it is possible to notice that the number of accidents due to faults or malfunction is lower or substantially equal to the one produced by other causes.

Data has been analyzed in such a way to show accidents according to deviation from standard behaviour; it could be possible to observe that the greatest part of accidents are due to causes like slipping, stumbling, falling, wrong body movement with or without physical stress, as far as shock, fright, aggression and so on.

Another great part of accidents is due to loss of control of means of transport, tools or machine; these accidents can be related to a malfunction but also to a wrong worker's behaviour or to other factors.

There are, without any doubt, accidents strictly related to faults, as electrical problems, explosions, fire, overflow, breakage, collapse, but their total number is not prevalent if compared to the other causes. Besides, there isn't a meaningful incidence of this kind of deviation even as regards consequences seriousness.

Table 1. Deviations from standard behaviour and related accidents.

	Temporary injuries	Permanent injuries	Death
10 Deviation due to electrical problems, explosion, fire	3.567	230	47
20 Deviation by overflow, overturn, leak, flow, vaporisation, emission	28.965	622	36
30 Breakage, bursting, splitting, slipping, fall, collapse of Material Agent	98.887	3.912	114
40 Loss of control (total or partial) of machine, means of transport or handling equipment, handheld tool, object, animal	333.168	13.722	561
50 Slipping - Stumbling and falling - Fall of persons	108.783	7.996	163
60 Body movement without any physical stress (generally leading to an external injury)	165.294	5.347	107
70 Body movement under or with physical stress (generally leading to an internal injury)	89.768	2.412	28
80 Shock, fright, violence, aggression, threat, presence	9.726	457	32

Then it's important to consider another aspect: the most widespread size of enterprise. Looking at ESAW and ESWC (European Survey on Working Conditions) documents, the majority of workers fit into category of SME.

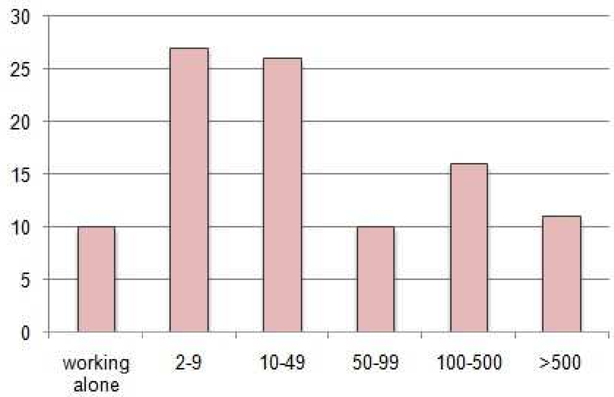

Figure 1. Workers percentage by company size.

In general the incidence rate of accidents at work is higher in small and medium size local units as compared to local units employing more than 250 employees.
Besides, workers in the smallest companies are less likely to wear personal protective equipment. In local units with at least 50 workers, about 30% wear personal protective equipment half or more of the time as compared to 14% of those working alone or 22% of those working in local units with 2 to 9 workers.

Figure 2. Accidents by company size and economic activity.

Figure 3. Workers wearing PPE by company size and economic activity.

These considerations move once more attention from reliability to manpower. Besides, occupational health and safety is even more important in SMEs since their core competencies are based on skilled manpower. Absence due to accidents at work can have higher consequences in terms of productivity for a small enterprise than for a large one, where employees can be easily interchanged.
RATE (Risk Analysis by Threshold Evaluation) was born just as specific methodology for OHS evaluation in SMEs, and take origin from two important observations.
The first one is that the main methodologies that were developed taking in account OHS problems more than reliability, like HAZOP for example, give only qualitative results; in other cases, like methods proposed by UNI EN 1050, by standard MIL-STD-882c and by AISS, we can see that analysis are based on not-dimensional values, fixed by analyst on his personal experience. So quantitative analysis doesn't have any link with real data.
Following this point of view, we can find other authors' works, as for example [8], where a new qualitative tool for OHS is developed; as regards SMEs, [7] proposed a methodology based on not-dimensional values.

By the other hand, authors that look after reliability methods mainly study great risks; particularly there's not attention about SMEs, following the idea that to solve great firms safety problems means to solve SMEs problems too.

An important improvement of these methodologies derives from those authors that introduce the human factor, as for example [6]; however, it might be observed that an important point in [6] is the introduction of operator support systems OSS that often cannot be proposed in SMEs because of the lack of resources and less sensibility about safety, as shown *Figure 3*.

Besides, there are some operations, especially in SMEs that preserve artisan or simply processing, that could not be subjected to automation.

In any case, it is never made a comparison between results that can be obtained in the two different approaches; the fact that research goes on in such a separate way, suggests a second observation.

This second observation is that reliability methods are hardly adaptable when the main aim is to obtain a quantitative assessment of risk for workers, because there are some important OHS features that traditional reliability methods can't easily match, as will be described afterwards in the paper.

We will compare hypothesis and procedures which reliability methods and RATE are based on, to give evidence at the main approach aspects that have to be modified in order to move from reliability to OHS.

2. Hidden risks

First of all, to face OHS problems, it is necessary to define which are the risks for workers that have to be quantified by a methodology.

Studying the problem of accidents causes, we realize that there are a lot of risks, that we called "hidden risks", that are due to relationships between different system elements, workers included; relationships that usually are not taken into consideration because they're unexpected and not necessary in processing.

Often no one realizes the presence of this relationships, because they're due to wrong behaviours, wrong layouts, or just to the fact that frequently, in SMEs, operations are not precisely codified and organized; so there is a degree of freedom and uncertainty in workers operations.

This fact distinguish substantially a SME from a big company, where the presence of production lines, defined roles and duties and a very high degree of automation allows to define risks related to operations in a more precise way.

That is to say that a big company is a system where, if two operations are related, relation type and mode is known and where, in any case, deviations from standard behaviour are probably due to system faults.

In such circumstances, relationships usually considered in analysis are only the ones between machines included in a production line, or between workers and machines, reflecting the idea that accidents can be due only to system malfunctions.

As regard SMEs, instead, the presence of other kind of "unexpected relationships" must enforce the idea that the whole system is not simply the sum of its parts, but that it's necessary to give great importance also to other elements that appear only when the parts are considered as related and not only as single units.

For example this "hidden risks" could be interferences between different operations that take place in the same area but that have nothing to do one to another; so risks for workers are related to geometrical elements or logistics, not to machinery faults. In this case it is clear that operations considered as single units could be safe, but the same could not be said for the whole system.

In this case work environment has a role in producing risks, as happened also if we take into consideration other OHS aspects, not related to accidents, as professional diseases.

It is clear that events harmful to health, not instantaneous as accidents but long-term as the exposition to various physical agents, inadequate working stations and so on, could not be neglected, as shown from ESWC interviews.

Trying to understand if traditional reliability methods can find this kind of risks and if it's possible to adapt them for a quantitative analysis of OHS, we face an objective difficulty in application because of the approach followed by these methodologies.

For example if we try to use a fault tree analysis to find and quantify risks for workers, we can see that the Top Events increase excessively if compared with a reliability analysis, because dangerous events for workers, from an OHS point of view, are innumerable.

It's not possible to reduce the Top Events number on which pay attention, because, if you look at the consequences for workers, all these events have a comparable importance: as a matter of fact, data confirm that it is not possible to associate specific consequences at deviations from standard behaviour, neither in terms of type of injury nor in terms of seriousness of injury.

So, it's almost impossible to detect all Top Events without following a precise scheme for their individuation; in any case the subsequent risk analysis will be particularly time consuming.

There is a sort of "weakness" of these methodologies as regards the determination of Top Events: they have to be fixed by analyst, therefore it must be observed that traditional methods as FTA cannot find

the "hidden risks" simply because they have to be an analyst's hypothesis.
So OHS is an ambit where comes out the fundamental necessity to define a procedure able to identify methodically all risks for workers.
This is what we do in RATE, and that is its first feature: create a graphical scheme that could be a complete representation of all possible interactions between system elements, under the hypothesis that risks derive only from these interactions or from elements themselves.
The scheme is then functional to show all possible risks for workers; it's analyst duty only to associate the correspondent risk value.
That is to say, we think is fundamental that analysts don't have to fix Top Events on their personal experience, but simply follow a procedure that brings them to find all risk as easily and objectively as possible.

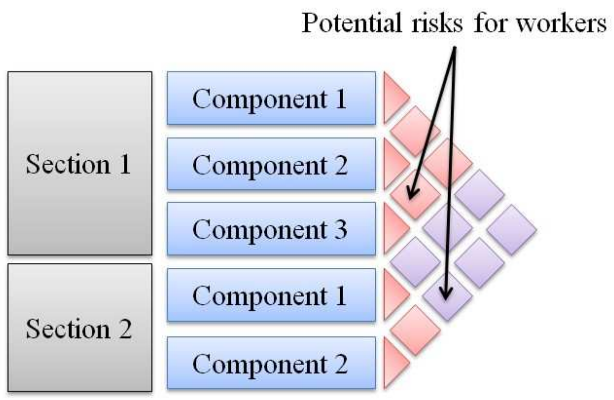

Figure 4. Risk matrix

So the analyst divides a system in sections and components, creating the risk matrix illustrated in *Figure 4*. Every matrix cell can contain an interaction between components, that is to say a risk for workers.
Methodology simplicity is then assured from the fact that, looking a scheme comprehensive of all potential interactions, is enough that the analyst makes an easy comparison between couples of components to identify risks that really exist.
The possibility, given from matrix, of comparing couples of components even if belonging to different sections, to different operations or to different workers, even if completely disconnected to each other, is just what assures the individuation of "hidden risks".
However, it is clear that RATE objectivity and goodness of results are related to precise definitions about the way to divide system in sections and components.
Once created a right system scheme, the key point is the availability of a value to assign to every risk.

3. Useful data for risks quantification

Another reason why it's difficult to apply traditional reliability methods to OHS, is due to type of data: they're referred to faults, so are inadequate to quantify risks for workers that depend from causes different from faults.
So RATE uses data on accidents at work as a base for risk analysis, because we think that homogeneity between input data and waited results is fundamental for a correct approach.
Frequency of injuries is not commonly available or quickly evaluated for a small enterprise. Accident data eventually recorded might be not statistically significant due to the relative low number of occurrences.
But, differently from what happens with failure rates, there is an European database where it is possible to find a large amount of data on accidents at work; data are collected in an homogeneous way in fifteen nations following a methodology called ESAW.
As regards collecting information about professional diseases, a methodology called EODS (European Occupational Diseases Statistics) has been prepared to create another European database. At this stage data are not recorded with an amount of detail to enable their use inside a risk assessment methodology, but they could be an interesting future development.
So in RATE methodology, we establish to use ESAW data to calculate risk values that have to be associated to every interaction founded by analyst in the risk matrix.
Following ESAW methodology, accidents are collected by a certain number of variables; so data can be selected using this variables and become more and more specific.
It is then possible to obtain specific occurrence frequency for every economic activity, type of deviation, mode and type of injury, size of enterprise, geographic location, and so on.
Data to be used in RATE are selected by economic activity, contact (that is to say a mode of injury), and number of days lost.
It's then clear how this procedure brings analyst to find just risks for worker and not failures or generic events: as a matter of fact, when the analyst find an interaction he identifies a mode of injury for worker, choosing from a list including hundred type of contacts defined by ESAW.

4. Results accuracy

Attend to OHS in SMEs, implies another different point of view that should be a key point for a risk assessment methodology: available of results for workers, that is to say an easy display of results and methodology ability to give evidence to risks and the necessary safety devices that have to be used for their reduction.

So the idea is that methodology may induce an approach where analyst evaluate-compare-correct, in a very easy and direct way; in a way that could be understood from workers and lead to the growth of their sensibility with regard to safety.

In other words the aim is to obtain a methodology that could be used for design; this means the possibility to have a threshold value that permits SME to easily know how much it is far from an acceptable safety level.

The importance of this threshold will be best explained below; first it's necessary to underline that this simplicity, the fact we want results available and comprehensive for workers, is not exactly related to a precise quantification of events but rather with a system safety assessment.

So we consider acceptable for a SME that output values could be approximate, as long as they are statistically meaningful. Results accuracy is then another aspect which makes RATE approach very different from reliability traditional methodologies.

The approximation we introduced interests two different aspects: elaborations that have to be made on frequency data on accidents at work to find risk values that have to be associated to interactions; calculations that have to be made to find the analysis final result starting from single risk values.

In the first case the idea from which we started is that risk values have to be assigned to interactions in a very easy and intuitive way, for example using values taken from tables, as happens in civil engineering where load values stressing a structure are provided from technical law.

This gets rid designers of necessity to establish exactly real values acting on structures, on the basis that values provided are the result of large statistical analysis, that designers may not be interested to. Clearly, this is an "approximate" approach, because the structure is not verified exactly in all configurations in which it will be.

Taking inspiration from this methodology, in RATE "characteristic" risk values are derived from statistical data; once calculated these characteristic values, analysis can be made without take into consideration the data origins.

It must be observed how, in civil engineering, this approach is accepted as long as designer considers a standard situation: when he calculates a structure far from standard behaviour he must assign particular loads, found with specific and more precise investigations.

So the approach differences between RATE and traditional reliability methods become even more evident: if safety is analyzed in SMEs, it is acceptable to consider a standard behaviour and can be satisfied by a risk assessment; instead, in case of great risks and particular systems, as for example the chemical ones, it is necessary an approach that searches for precision, as reliability methods do.

Characteristic risk values in RATE are obtained starting from the examination of frequency data and from the observation that less serious accidents happen more frequently and occurrence frequency goes down when consequences seriousness increase. So we decided, following data trend, to fix magnitude as the inverse of mean frequency value in order to obtain a mean risk value of one. This means risk value represents a generic accident and all other accidents will have a characteristic value higher or lower than one proportionally to the frequencies data (Paragraph 6).

Even as regards calculations that have to be made subsequently to combine single risks and obtain section risk indexes (that represent the global measure of system safety and the analysis final result), hypothesis on which RATE is based, are quite different from the ones adopted by reliability methods.

In these last methodologies, a precise analysis is made for every Top Event, which aim is to describe exactly the event and all its consequences; this is rather improbable as regards to accidents for workers because there can't be any certainty about the consequences of an anomalous event when we speak about human beings and not mechanical systems.

So we decided to follow once more Limit States methodology for civil engineering: here concurrent factors for combining loads are provided in order to take in account the reasonable sceneries that may develop.

Similarly in RATE we establish to use concurrent factors to take into account the fact that more than one risk could happen at the same time, because risks are related each other or because operations that take place in adjacent areas can suffer from consequences of events that have occurred in the vicinity.

Starting from this assumptions we decided to fix concurrent factors on the basis of the number of matrix cells that have been filled; so a factor will be higher if in the same section there are a lot of risks, that is to say there is an high probability that there will be simultaneousness.

As we said, this is an approximate procedure, not an exact one, but it takes reasonable in account this phenomenon and allows to maintain the desired method simplicity: as a matter of fact, analyst doesn't have to establish all possible links and consequences coming from or producing a Top

Event, but have only to consider relationships between two elements.
In any case, the aim is to get over the laborious elaborations that bring to a precise risks quantification and move towards an approach where risk is estimated, where it's possible to take in account effects like simultaneousness without being forced to identify them with precision.
A method where few factors represent a complex configuration and allow not to worry about further specifications.

5. Threshold value and safety devices

Therefore, the only aspects on which analysts have to pay attention are a good initial scheme that brings to a complete risks identification and the choice of safety devices that have to be introduced to bring risk indexes of every section under threshold value.
Further differences that come out as regards to reliability methods depend first of all from the fact that safety devices are not considered as system parts and included in analysis but introduced later as corrective measures for safety problems.
Then there is a clear threshold value to establish results acceptability, differently from traditional methods where are available only generic references provided from technical literature for great accidents.
In RATE instead threshold guides the analyst in safety devices identification, assuring system correction and improvement.
Data that can show the influence of safety devices on accidents frequency are not available; as a consequence in RATE devices are introduced by a safety factor able to express an efficiency level following this rule:

- 100% risk reduction if safety devices fully erase the problem;
- 80% risk reduction if safety devices are automatically activated;
- 50% risk reduction if safety devices are activated by workers.

We underline once more as this factor represents only an assessment of the real possibility of risk reduction from a safety device; in any case we think that this assessment is coherent with RATE hypothesis.
In the same way, threshold value for comparing analysis results is the unit value representing the generic risk: as a matter of fact it represents the possibility that one risk takes place inside one section; all sections that will have a risk index lower than one could be considered reasonably safe.
Take the unit value as threshold have double meaning: consider acceptable an improvement of the mean general situation and consider acceptable a remaining part of risk, that is to say that it is not possible to reach a risk value equal to zero.
This may seem "not too much" for prevention, but it must be noticed that take as target an improvement of the mean situation, means reducing the total number of accidents over time.
Under this hypothesis the unit value will gradually become representative of a lower number of accidents: this is equal to consider a lower threshold value, so safety measure will be more restrictive over time.

6. Brief RATE presentation

In order to provide a clear explanation of RATE methodology, we summarize here the procedure.
When applying RATE a system is analysed according to a functional logic, that will lead to the identification of the following elements:
Section: a portion of the process that can be considered independent from a logical or functional point of view.
Component: a part of the system which can be physical, geometric or spatial as far as a process fluid or material, operator, etc. having an active role in the process.
As we said before, at this stage any safety device the system has been provided with is not considered, but will be introduced later in analysis.
After splitting the analysed system into its sections and components, it is necessary to build the risk matrix in *Figure 4*, where risks arising from interaction of such elements are identified and coded.
So a cell (i, i) in the risk matrix is filled only if component i represents a potential source of danger for the worker.
In the same way, a cell (i, j) is filled if the interaction between the i-th and the j-th component may lead to a risk for the operator.
It must be underlined that risks to be considered are not only those coming from interaction of components belonging to the same section, but also those coming from the interactions between different sections.
Once identified all possible risk for workers, frequency and magnitude should be quantified in order to assign a value to every cell in the risk matrix.
So analyst uses data on accidents at work coming from EUROSTAT or national agencies database, selecting them by ESAW variables called "economic activity", "contact – mode of injury", and "number of days lost", in order to find three level of frequencies data, one for temporary injuries, one for permanent injuries, one for death, related to contacts happened in the sector of the company he's analyzing.

Then he calculates the mean frequency value in the three severity cases and fix magnitude as the inverse; magnitude is then multiplied with frequency value of every contact. At the end analyst adopts the mean value of risk as characteristic risk value. See for example *Table 2*.

Table 2. Calculation of characteristic risk values in manufacturing sector.

	Temporary injury	Frequency	Risk	Permanent injury	Frequency	Risk	Death	Frequency	Risk	Characteristic risk value
49 Other group 40 type Contacts	745	0,08	0,04	42	0,00	0,06	1	0,00	0,04	0,05
50 Contact with sharp, pointed, rough, coarse Material Agent	27816	3,16	1,55	892	0,10	1,21	10	0,00	0,43	1,06
51 Contact with sharp Material Agent (knife, blade etc.)	97.228	11,05	5,42	2909	0,33	3,93	37	0,00	1,59	3,65
52 Contact with pointed Material Agent (nail, sharp tool etc.)	26.703	3,04	1,49	544	0,06	0,74	11	0,00	0,47	0,90
53 Contact with hard or rough Material Agent	112.916	12,84	6,29	4.164	0,47	5,63	79	0,01	3,40	5,11
59 Other group 50 type Contacts	1565	0,18	0,09	48	0,01	0,06	0	0,00	0,00	0,05
60 Trapped, crushed, etc.	4.154	0,47	0,23	205	0,02	0,28	15	0,00	0,65	0,38
61 Trapped, crushed - in	8.288	0,94	0,46	445	0,05	0,60	12	0,00	0,52	0,53
62 Trapped, crushed - under	36.867	4,19	2,05	1521	0,17	2,06	58	0,01	2,50	2,20
63 Trapped, crushed - between	28.827	3,28	1,61	1378	0,16	1,86	34	0,00	1,46	1,64
64 Limb, hand or finger torn or cut off	1.771	0,20	0,10	546	0,06	0,74	3	0,00	0,13	0,32
69 Other group 60 type Contacts	348	0,04	0,02	21	0,00	0,03	0	0,00	0,00	0,02
70 Physical or mental stress	2.741	0,31	0,15	99	0,01	0,13	1	0,00	0,04	0,11
71 Physical stress - on the musculoskeletal system	90.491	10,29	5,04	2534	0,29	3,42	26	0,00	1,12	3,19
72 Physical stress - due to radiation, noise, light or pressure	449	0,05	0,03	7	0,00	0,01	0	0,00	0,00	0,01
73 Mental stress or shock	150	0,02	0,01	11	0,00	0,01	1	0,00	0,04	0,02
79 Other group 70 type Contacts	263	0,03	0,01	11	0,00	0,01	3	0,00	0,13	0,05
80 Bite, kick, etc. (animal or human)	473	0,05	0,03	3	0,00	0,00	1	0,00	0,04	0,02
81 Bite	368	0,04	0,02	14	0,00	0,02	0	0,00	0,00	0,01
82 Sting from insect or fish	307	0,03	0,02	7	0,00	0,01	1	0,00	0,04	0,02
83 Blow, kick, head butt, strangulation	1.676	0,19	0,09	68	0,01	0,09	2	0,00	0,09	0,09
89 Other group 80 type Contacts	193	0,02	0,01	9	0,00	0,01	0	0,00	0,00	0,01
99 Other Contacts - Modes of Injury not listed in this classification	2.624	0,30	0,15	110	0,01	0,15	11	0,00	0,47	0,26
Total number of accidents	843.875			34.780			1.091			
Mean risk value			**1,00**			**1,00**			**1,00**	**1,00**

Then, by equation (1), analyst can realize a combination of identified risks to take in account links and simultaneousness; the final output is a Risk Index (RI) for every section:

$$RI_i = CF_i \cdot R_i + \sum_{i \neq j} (\psi_i \cdot CF_j \cdot R_j) \qquad (1)$$

where:
R_i = risk of the i-th section of the system, calculated as the sum of the risk values in the cells of the section;
CF_i = concurrent factor for section i, calculated as the ratio between the number of cells identified as risk sources and the total number of cells of the same section;
Ψ_i = system concurrent factor for the i-th section, calculated as the ratio between the number of filled cells of the section and the total number of cells in the risk matrix.
This is called "Basic RI", because it is calculated considering the system without any safety measure installed, with the aim to make workers aware of the most intrinsically dangerous sections of the system.
At last this risk indexes can be reduced adding to system all safety devices needed to bring indexes under a threshold value.
In particular, safety measures act reducing the component risk r_k of each section S_i by the safety factor (SF) we introduced before.

When safety measures are introduced RIs are calculated as follows:

$$RI_i = CF_i \cdot (R_i - \sum_{k \in S_i} SF_k \cdot r_k) + \sum_{i \neq j} \psi_i \cdot CF_j \cdot (R_j - \sum_{k \in S_j} SF_k \cdot r_j) \qquad (2)$$

Analyst can obtain an Actual RI if he's analyzing a system already protected by some devices, or a Design RI when he takes in account all the possible additional safety measure that will be introduced to protect the system.
In both cases the reference to consider acceptable the results is provided from the comparison of RIs with threshold value, as shown in *Figure 5*.

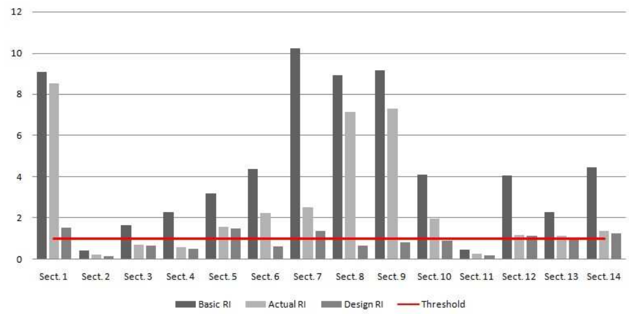

Figure 5. Example of comparison with threshold value.

7. Conclusion

It's clear that, historically, the attention on safety problems might start from the biggest risks and from the most dangerous systems, but it's also clear that the interest in this problems produced, over time, an increasing sensitiveness on safety, that now brings to pay attention also at small enterprises and at "small risks" that characterize them.
So we think that it's necessary to introduce a clear distinction between great risks and the "small" ones, that is to say between risks that interest a lot of people inside and outside the factory, and risks related to one or a little number of persons while they're doing their ordinary duties.
The last one's low seriousness doesn't have to bring to a superficial approach because they have often a high frequency, because, if we consider the whole productive system, they're related to a great number of workers, and at last because, if nobody takes care about them, there will be never developed effective safety devices, better than the existent ones.
These risks must not be neglected, and it's necessary to convince ourselves that approach and methodologies developed for great risks analysis

can't be simply "adapted", because they're based on different and inappropriate hypothesis.

Furthermore, if aspects as methodologies simplicity or complexity could be neglected because they could be not relevant if results are good, it must not be forgotten the presence of "weaknesses" in reliability methods, due to the absence of an objective way to find Top Events which analysis starts from, the absence of data as failure rates, the absence of a threshold value to compare analysis results.

These are the main problems which RATE gives solution, fixing a procedure to identify risks, using data on accidents at work that are available, up-to-date, homogeneous, related to a great number of occurrences European Union-wide, and at last introducing a threshold value that allows to provide an effective instrument for benchmarking too, both between companies belonging to the same sector and between companies belonging to different geographical areas, providing results that could give evidence to differences between different European states or regions.

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