Impact Assessment of Eight Year Application of the SOL Safety Event Analysis Methodology in a Nuclear Power Plant

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Abstract: The objective of this paper was to summarize the measurable indicators of the impact of eight year application of the SOL safety event analysis methodology in the period of 2007 – 2015 in a nuclear power plant in Hungary. The theoretical framework of this paper consists of the (1) "Swiss-Cheese Model", (2) the "socio-technical system model", (3) the organizational learning approach, and (4) the concept of safety culture. The selected broad spectrum of methods corresponds to the approach of progressing from the actual state of the safety culture – via covering the SOL related experiences and opinions of the most involved employees, middle and top managers, and training experts as well – towards the whole community of the NPP. As the results of widespread questionnaire surveys, focus group interviews and anonymous intranet-based inquiry methods it can be stated that the overwhelming majority of the respondents considered the application of the SOL methodology as useful and supporting the safety-related organizational learning. It was also found, however, that in the respondents' opinion the utilization of the – otherwise correct and deeply penetrating – results of SOL analyses is still to be improved.

Keywords: SOL; safety event analysis; nuclear power plant

1   Introduction

1.1   Background

This paper is the second of two related papers providing fundamental information on the experiences gained during applying the SOL safety event analysis methodology in the MVM Paks Nuclear Power Plant Ltd. (hereafter - Paks NPP) in Hungary.

The first paper, entitled '*Factual results of eight year application of the SOL safety event analysis method in a nuclear power plant*', dealt with general factual findings. The goal of the present paper is to present the impact of introducing the SOL methodology on the safety culture of the Paks NPP. The fundamentals of the SOL methodology have already been published elsewhere in many journal articles and books, e.g. refer to [4], [5], and in [3]. Some IAEA (*International Atomic Energy Agency*) and EC (*European Commission*) technical documents also review the SOL, refer, e.g. to [6], [8] and [2]. More details about applying the SOL at Paks NPP can be found in our first paper.

1.2   Research Questions

Based on the demands from the top management of the NPP and also on our earlier experiences, the following main research questions have been selected for studying.

• What is the general opinion of the employees about the usefulness of the SOL methodology in this NPP?

• What are the added values of SOL analyses compared with the routine event investigation methodology in the opinion of the employees?

• Who are the main beneficiaries of SOL analyses in the opinion of the employees?

• To what degree do they consider the utilization of the results of SOL analyses satisfactory?

• How all the opinions above depend on the position and professional areas of the respondents?

2   Methods

2.1   Approach

The theoretical framework of this paper consists of (1) the "Swiss-Cheese Model", (2) the "socio-technical system model", (3) the organizational learning approach, and (4) the concept of safety culture. Since (1), (2) and partly (3) accident causation models are touched in our first paper, here we focus partly on (3) and mainly on (4).

We accept the definition of the [1]: organizational learning is an organization-wide continuous process that enhances its collective ability to accept, make sense of, and respond to internal and external change. All organizations learn, in the

sense of adapting as the world around them changes. The big differences between organizations are, however, that some organizations are faster and more effective learners. Concerning the operational teams, as smaller units of organizations, similarly, the big safety-relevant differences between them are that some teams are better cooperating and more adaptive learners (refer to [15] and [16]).

The term "safety culture" was first introduced by the International Nuclear Safety Advisory Group (INSAG) in 1986 as a response to the Chernobyl disaster. The INSAG later introduced the presently used following definition of safety culture in its [10, page 4] report: "Safety Culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance." For other aspects of safety culture in nuclear installations refer to [9] and [10], [11].

2.2   Applied Methods

2.2.1   Studying the Results of Safety Culture Assessments

An analysis of documents and reports on different safety culture assessments since 1999 carried out in the Paks NPP using the basic questionnaire-based assessment methodologies proposed by the IAEA [7] has been completed.

2.2.2   Questionnaire Survey among Employees Who had already Taken Part in SOL Analyses

Within our whole target period of interest (2007 March – 2015 May, totaling up to about 8 years) there were four two-year sub-periods (2007-08, 2009-11, 2011-13, 2013-15) for each of which a separate SOL meta-analysis was carried out thus covering altogether 27 individual SOL event analyses.

In this survey the participants of SOL analyses and meta-analyses had been asked to weight the significance of problems identified during SOL analyses. The aim of this survey was to map the opinions of all the employees who had already taken part in SOL analyses concerning the most serious actual safety-related problems as a function of time (in terms of the data gained in the four subsequent meta-analyses). These opinions were considered as important reflections of the impact of the application of the SOL on the safety culture of the NPP.

These opinions were asked on a 3-point "seriousness" weighting scale, the anchor points of which were defined as follows:

(1) Not real problem, or already solved

(2) Problem solving in progress

(3) No progress made

Before each meta-analysis all the employees who had already taken part in SOL analyses until that time were asked to select those 5 problems that they judged as most serious, and later to weight them on the "seriousness" scale presented above. These individual weights were summed up to each problem and finally all the problems were arranged into a list of descending total weight order. The first 15 problems in this list were taken as the most "serious". Similarly, the participants of the actual SOL meta-analysis also were asked to select those 5 problems that appeared to them to be the most serious ones, and later they also had to weight these on the "seriousness" scale. These individual weights were again summed up to each problem and finally the problems were arranged into a list in descending total weight order. The first 25 problems in this list were taken as the most "serious".

Table 1

The process of identifying and weighting the safety-related problems based on SOL analyses

Time sub-period of SOL analyses	Number of performed SOL analyses	List of earlier 15 most „serious problems compiled by	List of present 25 problems compiled by	Unified list of 40 most „serious problems re-weighted by
2007-2008 1st meta-analysis	8	none (as still there were no "earlier" problems)	the participants of the 1st SOL meta-analysis performed in 2008	none (as still there were no "earlier" problems)
2009-2011 2nd meta-analysis	8	the participants of all SOL analyses performed in the period of 2007-2011	the participants of the 2nd SOL meta-analysis performed in 2011	the participants of the 2nd SOL meta-analysis performed in 2011
2011-2013 3rd meta-analysis	6	the participants of all SOL analyses performed in the period of 2007-2013	the participants of the 3rd SOL meta-analysis performed in 2013	the participants of the 3rd SOL meta-analysis performed in 2013
2013-2015 4th meta-analysis	5	the participants of all SOL analyses performed in the period of 2007-2015 (194 persons)	the participants of the 4th SOL meta-analysis performed in 2015	the participants of the 4th SOL meta-analysis performed in 2015

Finally, the two lists were unified and re-weighted by the participants of the actual SOL meta-analysis resulting in the unified and re-weighted list of the 40 most serious problems. The weights were summed up separately for managers (for group leaders and above) and subordinates (for employees below the group leader position). In order to follow with attention the changes of seriousness of the perception of safety-related problems as a function of time, the overlaps of these lists belonging to different periods of times were studied.

2.2.3   Focus Group Interviews with Middle Managers

In the frame of the 2015 year SOL meta-analysis 12 opinion-shaper middle managers were participating in a focus group discussion to find answers to the following questions:

(1) What are the added values of SOL analyses for the participants and for the Paks NPP Company compared with the routine PRCAP (*Paks Root Cause Analysis Procedure*) event investigation methodology?

(2) Who are the main beneficiaries of SOL analyses?

(3) Is it expectable during all SOL analyses that the "truth" will come out concerning the given event?

(4) Are the SOL analyses well-documented?

Text analysis method was also used to summarize the different opinions.

2.2.4   Interviews with Top Managers about the Impact of Applying the SOL Methodology on the Safety Culture

The interviewees were the 13 top managers (directors, heads of main departments and heads of departments) who had already taken part in SOL analyses, and these interviews included giving scaled/numeric answers along the following dimensions

- SOL usefulness (on five-point scale)
  (*To what degree do you judge the SOL methodology useful?*)

- SOL notoriety among top managers (on five-point scale)
  (*To what degree do you judge the SOL methodology known among top managers?*)

- SOL notoriety among the wider managerial group (on five-point scale)
  (*To what degree do you judge the SOL methodology known among middle and lower level managers?*)

- SOL notoriety in the power plant as a whole (on five-point scale)
  (*To what degree do you judge the SOL methodology known among all the employees?*)

- SOL acceptance among top managers (on five-point scale)
  (*To what degree do you judge the SOL methodology accepted among top managers?*)

- SOL acceptance among the wider managerial group (on five-point scale)
  (*To what degree do you judge the SOL methodology accepted among middle and lower level managers?*)

- SOL acceptance in the power plant as a whole (on five-point scale)
  (*To what degree do you judge the SOL methodology accepted among all the employees?*)

- Percentage of SOL problem descriptions that got to decision makers (in percentage)
  (*Percentage of SOL problem descriptions that got to decision makers? %*)

- Percentage of SOL based measures taken (in percentage)
  (*Percentage of that SOL based measures that were taken? %*)

- Percentage of realization of SOL based measures (in percentage)
  (*Percentage of SOL based measures that were realized? %*)

In addition, the respondents gave also corresponding free textual answers.

The numeric answers – as values on ordinal scales – along the different dimensions were processed by statistical methods: relevant descriptive statistics were calculated and appropriate nonparametric tests were applied. The free textual answers were processed by text analysis.

2.2.5   Questionnaire Survey among Instructors of the Training Center

Since one of the most important and most frequent types of the utilization of the results of SOL event analyses is to train employees in order to avoid in the future the recurrence of certain problems identified by the SOL, the SOL related experiences, opinions and attitudes of the training staff are essential for shaping the safety culture.

Therefore, a questionnaire survey was carried out among instructors of the Training Center with the following main questions:

- How long has the respondent been qualified instructor (years)?

- Form of teaching: basic, drilling, refresher, department level, simulator training, maintenance training, e-learning, other. All answers on 0 (no), 1 (yes) scale

- Degree of knowing SOL methodology (3-point ordinal scale):

  (1) Does not know, only heard about it

  (2) Knows its fundamentals

(3) Has already participated in SOL analysis

- Degree of knowing SOL experiences made public in the portal (4-point ordinal scale):

  (1) Has not visited SOL reports on the portal, because has not been interested

  (2) Has already visited SOL reports on the portal

  (3) Regularly follows with attention SOL reports on the portal

  (4) Regularly follows with attention both SOL reports and normal PRCAP event investigations on the portal

- Considers the present posterior SOL analysis practice as useful: 0 (no), 1 (yes) scale

- Degree of utilizing SOL experiences in teaching practice (4-point ordinal scale):

  (1) Not yet

  (2) Refers to SOL analyses, but does not go into details

  (3) Presents some experiences of SOL analyses as convincing examples

  (4) Studies the experiences of SOL analyses in more details and organically builds them into the teaching as case studies

54 training staff members were directly asked to fill in the questionnaire.

2.2.6 Anonymous Intranet-based Questionnaire Survey about Applying the SOL Methodology

This and the following last method (section 2.2.7) are intranet-based approaches by the help of which it was hoped that a large part of the whole NPP community could be reached. The questionnaire survey finally involved 642 respondents, and asked the following main questions:

- Which directorate do you belong to?
  Production, Maintenance, Technology, Safety, Human Resources, Economic

- To what degree do you know the principles of SOL? (4-point ordinal scale):

  (1) Has never heard about SOL

  (2) Does not know, but has already heard about SOL

  (3) Knows the essence of SOL

  (4) Has already taken part in SOL analysis session

- Do you consider the SOL as useful? 0 (no), 1 (yes) scale

- Why do you consider the SOL as useful? (free text answer)

- Why do you consider the SOL as not useful? (free text answer)

- Do you know concrete measures that were taken based on the SOL?
  0 (no), 1 (yes)

- Comments and proposals concerning the use of SOL: (free text answer)

2.2.7 Log File Analysis of viSitors' Activity Concerning the Results of SOL Event Analyses Available on a Dedicated Portal of the Intranet of the Paks NPP

The number of SOL-related downloads from the portal of the NPP intranet was studied during the latest 15 months of the whole target period of interest.

For the date period of 2014.01.28 – 2015.04.30, the file request statistics were analyzed, as parameters characteristic for visitors' activity concerning the results of SOL event analyses.

3 Results

3.1 Safety Culture Assessments Carried Out by the Paks NPP

All the following assessments in this sub-section reflect the levels of safety culture perceived subjectively by the respondents. Therefore, these can be regarded as "opinions" collected in a methodologically appropriate way, rather than the "real" or "absolute" levels.

In 1998/99 and 2000 two of the authors [12] conducted two safety culture assessments at the Paks NPP based on questionnaires and interviews comparable with the methodology proposed by the IAEA [7] based on 26 sub-dimensions. The first assessment involved 153 subordinates, the second 63 managers. Although there were some minor differences in the results of these two assessments in certain sub-dimensions, the overall level actually was the same in these two samples (77% for the subordinates and 76% for the managers).

Later four more safety culture surveys were completed by the Aon Hewitt method in 2005, 2009, 2013 and 2015, involving also both subordinates and managers [13], [14]. The Aon Hewitt method – which usually produces slightly lower overall percentage levels than the IAEA method – is based on an anonym and voluntary questionnaire survey and the results comprise seven indices expressed in percentages and their average as one main summary index (overall percentage level). These indices (sub-dimensions) are: (1) commitment to safety, (2) procedure usage, (3) conservative decision making, (4) reporting culture, (5) treating unsafe activities and conditions, (6) organizational learning, (7) communication, clear priorities and responsibilities and transparent organization.

Of the above, the (6) organizational learning index directly relates to the values that the SOL also promotes and aims at developing, while all the others also relate to them but only rather indirectly.

It was found that from 2005 via 2009 to 2013 all the main summary indices showed slight increases or remained at constant levels in the range of 72-74%. Since the main summary indices of our 1998/99 and 2000 safety culture assessments by the IAEA method fit to this series, it can be taken that in the whole range of about 2000 to 2013 the level of safety culture increased only slightly or stayed constant. From 2013 to 2015, however, there was a radical 10% increase in the main index (from 74% to 84%). In this period the SOL related organizational learning index (sub-dimension) also jumped from 69% to 78%. This marked increase, among many others, may – or may not – be attributed to the influence of introducing the SOL method and disseminating its results in the NPP.

Studying the differences in the main index between directorates, positions and the time spent employed at the NPP revealed the following relationships:

- Concerning directorates, the highest differences were between the opinions of employees belonging to the Production Directorate and to the Maintenance Directorate. The opinions of the production staff were much more positive than that of the maintenance staff, who most often are facing with different unforeseen problems and deficiencies.

- Concerning positions, the highest differences were between the opinions of middle managers and the operative managers. The opinions of middle managers were much more positive than that of operative managers. Based on the results of a targeted focus group session, this effect could probably be interpreted by the fact that the operative managers are continuously working "between two fires": they are responsible for operative work, but simultaneously they also have to strictly observe all the related safety rules.

- Concerning the time spent at the NPP, the highest differences were between the opinions of most newer and most senior employees. The opinions of newer employees were very positive, but this value gradually decreased with the years spent at the NPP. Our interpretation of this finding is that while the most newer employees have an idealistic, a little bit still naïve, unrealistically positive overall picture about safety, the more experienced senior employees, on the contrary– based on their own occasional frustrations – might be slightly disappointed and may have an even more pessimistic view than the reality. One possible way to prevent this harmful mental process is to systematically and continuously show via many examples of how certain safety critical issues (identified e.g. by the SOL) are treated to forestall their serious consequences.

3.2   Questionnaire Survey among Employees Who had already Taken Part in SOL Event Analyses

For identifying and weighting the safety-related problems by employees who had already taken part in SOL event analyses the process presented in sub-section 2.2.2 (especially in Table 1) was applied. Since these results are very voluminous, here we only declare that the resulted rank order of the identified concrete particular problems was very useful for the managers and contributed to deeper understanding of the actual – both obvious and latent – risks. Three illustrating examples from this long ordered list (without their corresponding seriousness weights):

- The financial and human resources are not always matched to the tasks.

- Technological changes are often carried out under strong time pressure.

- The NPP cannot always properly provide the contractors and sub-contractors with the necessary training.

Another general experience was that although there is a moderate correlation between the weights given by the managers and subordinates (Spearman correlation coefficient $r_S = 0,718$; p=0,003), there are certain problems the seriousness of which are quite differently judged by managers than by subordinates. Analyzing and interpreting the details of this finding has also been proven useful for better understanding the managers' and subordinates' view.

3.3   Focus Group Interviews with Middle Managers

The interviewees were 12 opinion-shaper middle managers, who – in the frame of a focus group discussion as part of the 2015 year SOL meta-analysis – gave the following main groups of answers to the four predefined broad questions.

(1) What are the added values of SOL analyses for the participants and for the NPP compared with the routine PRCAP event investigation methodology?

- The SOL takes into account many aspects of events simultaneously, while PRCAP event investigations cannot do that.

- A big advantage of the SOL is that the participants can get to know other professional areas and their representatives, which is not true for PRCAP.

- The PRCAP practically always reveals equipment, system or human failures, while the SOL can identify organizational, leadership and procedure-related problems and thus can delve deeper into underlying causes.

(2) Who are the main beneficiaries of SOL analyses?

- First of all, the participants themselves, because they can get to know other professional areas and their representatives in more details.

- Provided that the utilization of results via managerial commitment will further be built and sustained, beneficiaries could be the wider professional areas.

- Since the problems identified by the SOL are mostly global NPP level malfunctions, the NPP as a whole could benefit from it.

(3) Is it expectable during all SOL analyses that the truth will come out concerning the given event?

- Although there have already been several cases in which the climate of SOL analyses was not honest, the truth usually still comes out.

- If the participants arrive at the SOL analysis „prepared", the chance is smaller.

- If the SOL analysis is conducted properly, the truth must come out, independently of the participants.

(4) Are the SOL analyses well-documented?

- The SOL documentation is appropriate, but in order to better utilize the results it is necessary to compile shorter targeted abstracts and circulate them.

- The reports contain the opinions of the participants, which is not necessarily the truth. Since even if the participants understand the problems correctly, the solution of them is already not their competence.

- Therefore, later an after-processing of the results would be necessary, and based on it, new, corrected documents have to be produced.

- The SOL documentation would be even better, if such experts were always participating in SOL analyses who can identify process-level problems.

3.4 Interviews with Top Managers about the Impact of Applying the SOL Methodology on the Safety Culture

The 13 top managers were interviewed by the authors. Parts of the results of the interviews were given in the form of scores on five-point scales and in estimated percentages, which made possible some simple quantitative statistical data processing. The main results are as follows.

Table 2

The main descriptive statistics of the scaled interview answers given by the 13 top managers about the impact of applying the SOL methodology on the safety culture

Interview question (answers on five-point scales)	Mean	SD
To what degree do you judge the SOL methodology useful?	4,15	0,899
To what degree do you judge the SOL methodology known among top managers?	4,92	0,277
To what degree do you judge the SOL methodology known among middle and lower level managers?	4,35	0,747

To what degree do you judge the SOL methodology known among all the employees?	2,96	0,967
To what degree do you judge the SOL methodology accepted among top managers?	4,27	0,599
To what degree do you judge the SOL methodology accepted among middle and lower level managers?	3,77	0,927
To what degree do you judge the SOL methodology accepted among all the employees?	3,33	0,888
Percentage of SOL problem descriptions that got to decision makers? (%)	68,08	27,729
Percentage of SOL based measures that were taken? (%)	42,46	31,853
Percentage of SOL based measures that were realized? (%)	30,38	26,037

Already these descriptive statistics in themselves are very informative. Emphasizing the most important ones, it can be seen, that respondents judged that:

- the application of SOL methodology is very useful (mean = 4,15; SD = 0,90),

- among top managers the SOL methodology is already almost perfectly known (mean = 4,92; SD = 0,28), and its acceptance is also rather high (mean = 4,27; SD = 0,60),

- among all the employees the notoriety and acceptance of the SOL methodology is already much lower (mean = 2,96; SD = 0,967 and mean = 3,33; SD = 0,89; respectively),

- the percentage that the problems identified by the SOL get to decision makers is 68% on the average, and these opinions have a relatively high dispersion (SD = 27,73),

- the percentage that the problems identified by the SOL result in measures is 42% on the average, and these opinions have an even higher dispersion (SD = 31,85),

- the percentage that the measures taken for solving the problems identified by the SOL is also realized is 30% on the average, and these opinions have again a very high dispersion (SD = 26,04).

Concerning the latest two points, these percentages could be increased by the continuous commitment of top managers to utilize the SOL results in practice.

Statistical comparison of the interview answer scores of the 13 interviewees by the Kruskal-Wallis test using the directorates where the interviewees belonged to (Production, Maintenance, Technology, Safety, Economic) as grouping variable, resulted in no significant differences. The comparison by the positions as grouping variable, however, produced two significant differences by the pair-wise Mann-Whitney test (Figure 1).

As Figure 2 shows, there was also a significant correlation between the perceived acceptance of the SOL methodology by all the employees and its perceived usefulness.
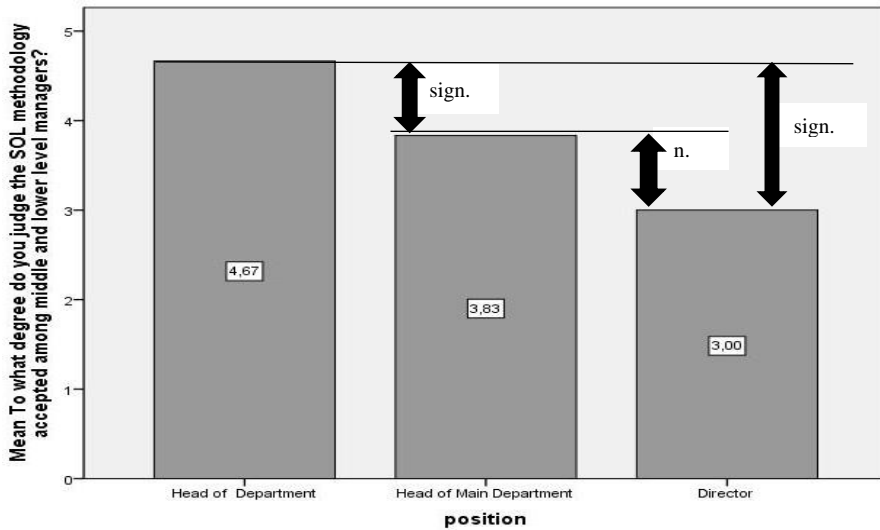
Figure 1
Acceptance of the SOL methodology among middle and lower level managers as a function of the
position of the interviewees. The differences indicated by "sign." are significant by the Mann-Whitney
test. Since the variable "To what degree do you judge the SOL methodology accepted among middle
and lower level managers?" presented on the vertical axis is measured on an ordinal scale, its means
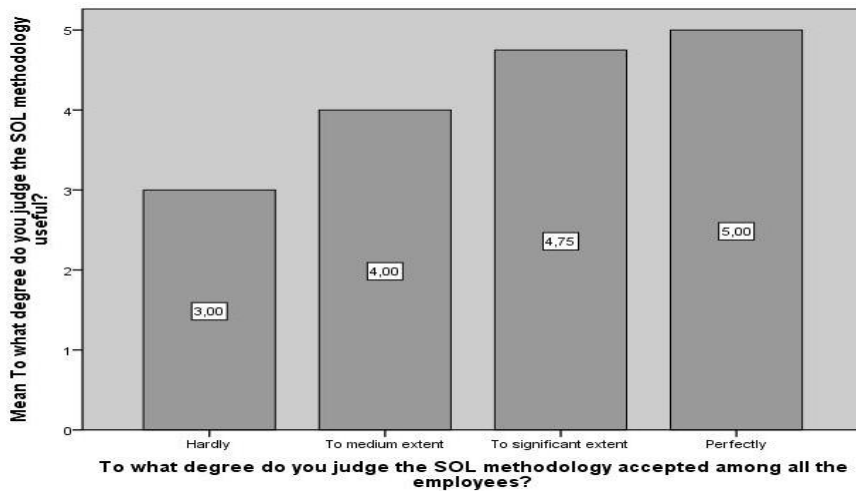are displayed only for visual demonstration purposes.

Figure 2
The degree of perceived usefulness as a function of the perceived acceptance of the SOL methodology
among all the employees (Spearman correlation coefficient $r_S = 0,715$; $p=0,009$). Since the variable
"*To what degree do you judge the SOL methodology useful*?" presented on the vertical axis is
measured on an ordinal scale, its means are displayed only for visual demonstration purposes.

Of the free text answers the following two were both the most important and most frequently mentioned: (1) "*Very useful methodology, but the utilization of results is still incomplete*"; (2) "*SOL really should be about learning and not finding someone to blame*".

3.5 Questionnaire Survey among Instructors of the Training Center

54 instructors filled in the questionnaire. Concerning the respondents' opinion about the usefulness of the present SOL analysis practice the majority (83,3%, 45 persons) answered "yes", the minority (16,7%, only 9 persons) answered "no".

The mean time spent in the "*qualified instructor*" position by this 16,7% minority was 10,11 years, which is significantly longer by the Mann-Whitney test (p=0,045), than that of the majority (6,96 years), who consider the present SOL practice as useful. This finding is interpreted by the well-known experience that the older instructors are less open for such new approaches like the SOL.

Among instructors who consider the present SOL practice as useful, the percentage of those who are conducting refresher training is 80%, while this percentage among instructors who consider the present SOL practice as not useful is only 44%. This difference is significant by the Mann-Whitney test (p=0,028). We interpret this result by taking into account that the refresher training is focused on actual daily problems for which the SOL analyses usually provide support. In addition, for instructors conducting refresher training to be familiar with the newest SOL results is a definite expectation.

Figure 3 shows the variable „*Form of instruction: department level*" as a function of the variable "*Degree of knowing SOL experiences made public in the portal*" on ordinal scale.
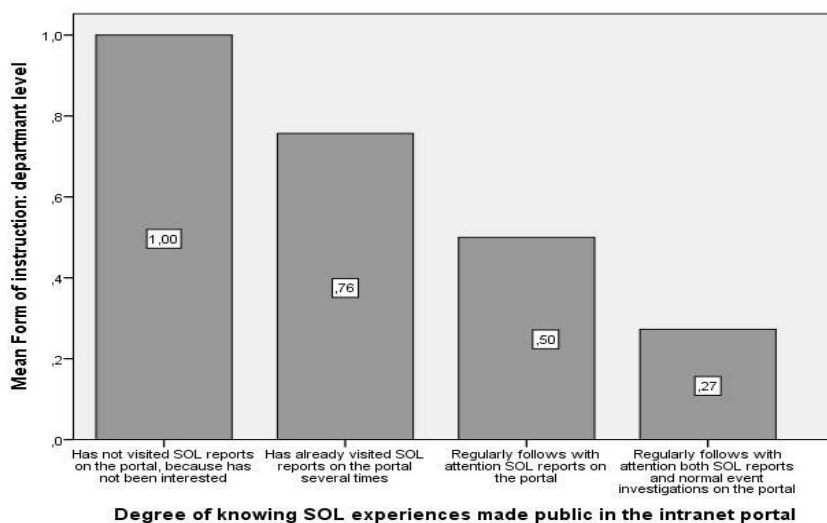
Figure 3
The mean of the variable „*Form of instruction: department level*" on dichotomous no(0)/yes(1) scale
as a function of the variable "*Degree of knowing SOL experiences made public in the portal*" on
ordinal scale. Both the Spearman correlation coefficient

($r_S = -0,451$; p=0,001) and the Kruskal-Wallis test (p=0,011)indicates a significant relationship.

It can be seen that in the category of lowest level knowledge about SOL experiences (*1: Has not visited SOL reports on the portal, because has not been interested*) there are exclusively instructors conducting department level training (100%), and their ratio is gradually decreasing with the growing levels of knowledge about SOL experiences (75,7%, 50%, 27,3%, respectively). We interpret this result by taking into account that the targets of department level instruction are relatively local problems and the instructors conducting department level instruction do not belong to the Training Center. There is no formal expectation toward them to follow with attention the newest SOL results, therefore only a smaller part of them was interested enough to be informed about recent SOL results.

Figure 4 shows the variable "*Form of instruction: simulator training*" as a function of the variable "*Degree of knowing SOL experiences made public in the portal*" on ordinal scale.
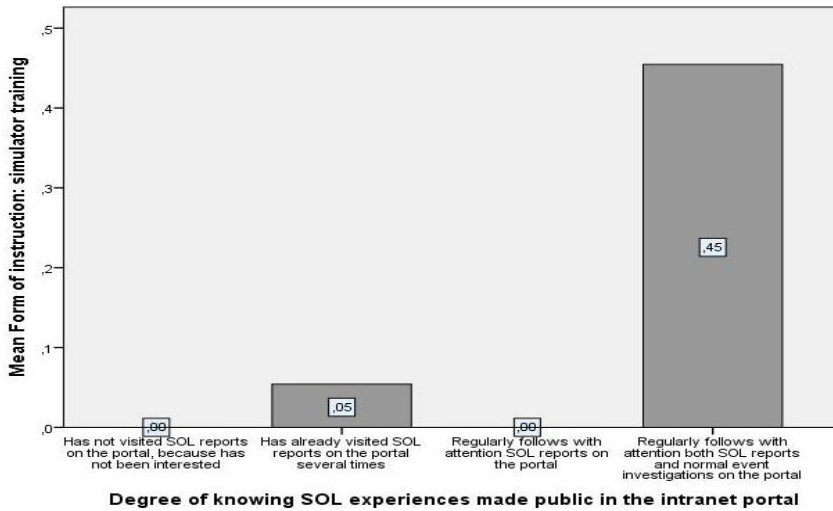
Figure 4

The mean of the variable "*Form of instruction: simulator training*" on dichotomous no(0)/yes(1) scale
as a function of the variable respondents' "*Degree of knowing SOL experiences made public in the
portal*" on ordinal scale. The Kruskal-Wallis test (with some additional procedures) indicates
($p=0,005$) that the proportion of simulator training instructors is significantly higher in the category of
"*Regularly follows with attention both SOL reports and normal event investigations on the portal*",
than in other categories.

It means that in the category of lowest level knowledge about SOL experiences (1*:
Has not visited SOL reports on the portal, because has not been interested*) there
are no instructors conducting simulator training at all (0%), and their ratio remains
about zero with the growing levels of knowledge about SOL experiences till level
3 (3: *Regularly follows with attention SOL reports on the portal*). In the category
of highest level knowledge about SOL experiences (4: *Regularly follows with
attention both SOL reports and normal event investigations on the portal*),
however, there are instructors conducting simulator training in a relatively high
percentage (45,5%). This case is quite the contrary of the instructors conducting
department level instruction, since toward the simulator instructors being
informed concerning the latest SOL results is a definite expectation.

3.6 Anonymous Intranet-based Questionnaire Survey about Applying the SOL Methodology

Altogether 642 employees filled in the questionnaire, of which 489 respondents
knew – or at least have already heard about – the SOL methodology (76%).

The distribution of all the 642 respondents along the directorates was the
following: Production (222), Maintenance (140), Technology (138), Safety (64),
Economic (51), and Human Resources (27).

The distribution of all the 642 respondents along the "*Degree of knowing SOL*" was: "*Has never heard about SOL*" (153), "*Does not know, but has already heard about SOL*" (170), "*Knows the essence of SOL*" (232), "*Has already taken part in SOL analysis session*" (87). Since this intranet-based questionnaire survey was anonymous, there could be certain overlaps with the other types of surveys applied and therefore cannot be taken as involving a strictly independent sample. However, because of its large sample size (642 persons); we are convinced that this is still a very valuable source of information.

The main results are summarized in the following.

Of the 489 employees who knew – or at least have already heard about – the SOL methodology 463 gave answers about the usefulness of the methodology. From these 463 persons 419 (90,5%) considered it useful and only 44 persons (9,5%) considered it not useful.

Near half of the respondents, (49.5%: 227 out of 458) knew cases where safety measures were taken based on the results of SOL analyses. The following figure provides the frequency distribution of the altogether 869 mentions along the four identified mentioning categories.
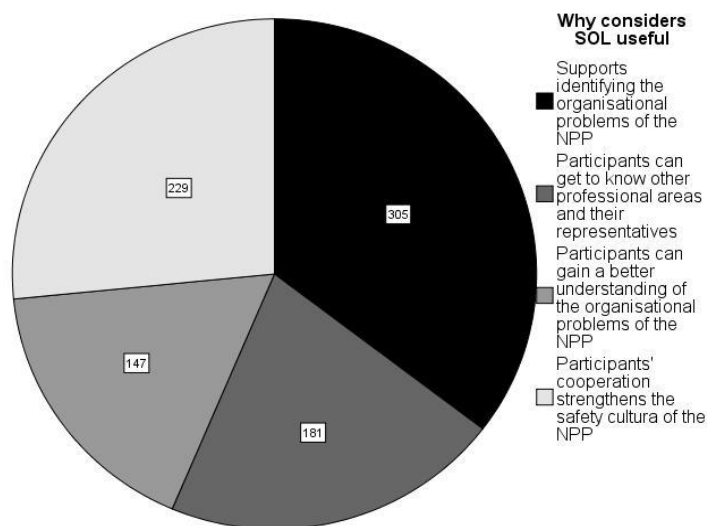

Figure 5

The distribution of the 862 mentions of the 419 respondents who considered the SOL methodology useful along four mentioning categories. Since multiple mentions were allowed the number of mentions is greater than the number of respondents.
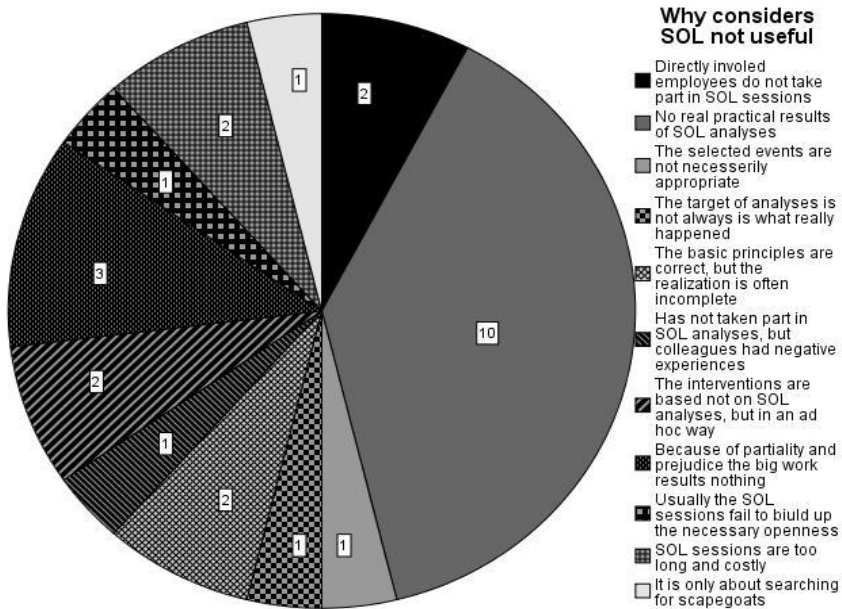
Why considers SOL not useful

- Directly involed employees do not take part in SOL sessions
- No real practical results of SOL analyses
- The selected events are not necesserily appropriate
- The target of analyses is not always is what really happened
- The basic principles are correct, but the realization is often incomplete
- Has not taken part in SOL analyses, but colleagues had negative experiences
- The interventions are based not on SOL analyses, but in an ad hoc way
- Because of partiality and prejudice the big work results nothing
- Usually the SOL sessions fail to biuld up the necessary openness
- SOL sessions are too long and costly
- It is only about searching for scapegoats

Figure 6

The distribution of the 26 mentions of the 44 respondents who considered the SOL methodology not useful along eleven mentioning categories. Although multiple mentions were allowed the number of mentions is lower than the number of respondents because the majority of these respondents gave no answer at all.

The following table summarizes the most frequent free text comments in descending order.

Table 3

The free text comments mentioned at least two times and their frequency of mentioning

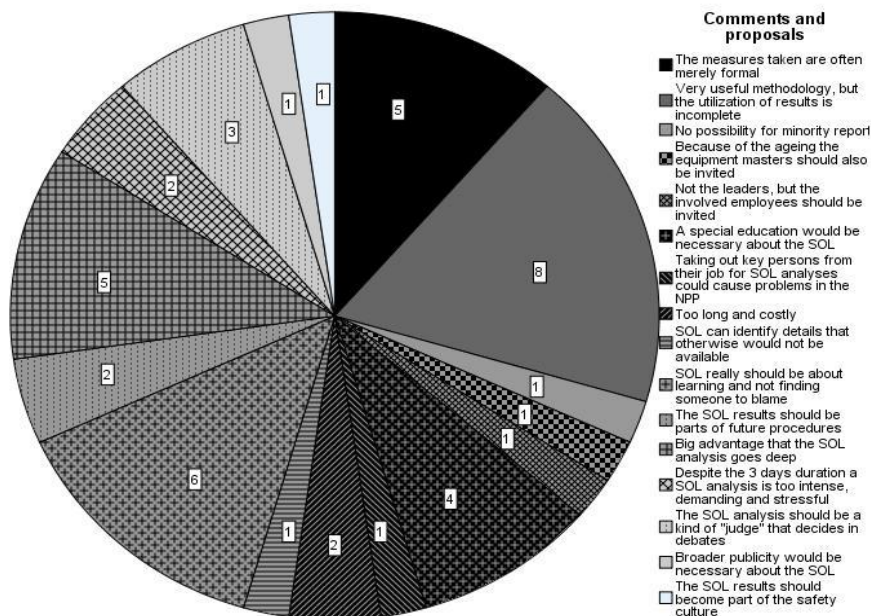| The comments and proposals	Frequency
Very useful methodology, but the utilization of results is still incomplete.	8
SOL really should be about learning and not finding someone to blame.	6
The measures taken are often merely formal.	5
Big advantage that the SOL analysis goes deep.	5
A special education would be necessary about the SOL.	4
The SOL analysis should be a kind of "judge" that decides in debates.	3
Too long and costly.	2
The SOL results should be parts of future procedures.	2
Despite the 3 days duration, a SOL analysis is too intense, demanding and stressful.	2

Figure 7

The comments and proposals of the 489 employees who knew – or at least have already heard about – the SOL concerning the SOL methodology

3.7 Log File Analysis of Visitors' Activity concerning the Results of SOL Event Analyses

The number of SOL-related downloads for the period of 2014-01-28 –2015-04-30, was first analyzed with the temporal resolution of one week, but as there was found no tendency along the time, only summary statistics are presented here in a simplified form and using English intranet link titles instead of the original Hungarian.

Table 4

The number of SOL-related downloads for the date period of 2014-01-28 – 2015-04-30.

(Only links downloaded more than20 times are indicated)

No	Intranet link	Number of file downloads
1	production_experiences/sol analyses	561
2	production_experiences/sol analyses/2015_1_sol_s31412.docx	120
3	production_experiences/sol analyses/2014_1_sol_s21321.docx	103

4	production_experiences/sol analyses/2014_2_sol_s11413j.docx	101
5	production_experiences/sol analyses/2014_3_sol_b31403j.docx	58
6	production_experiences/sol analyses/sol analyses content.doc	54
7	production_experiences/sol analyses/2013_meta_sol_report.docx	32
8	production_experiences/sol analyses/2007_1_sol_s30614.doc	23

If we consider here only the number of file downloads greater than 100, we receive the following files as a kind of top list:

- 2015_1_sol_s31412.docx,

- 2014_1_sol_s21321.docx,

- 2014_2_sol_s11413j.docx.

During the period of 2014.01.28 –2015.04.30, three SOL analyses were completed and these three files just contain the reports about them. It is obvious that employees are interested mostly in the results of most recent SOL analyses.

It is another question that downloads slightly greater than 100 during 15 months can or cannot be considered a significant number compared to the altogether 800 – 1000 potentially involved employees.

Our proposal for increasing the number of downloads is to arrange and organize the SOL related materials on the portal separately for the production, maintenance, technology and safety interest-groups.

4   Discussion

First of all, it is essential to emphasize that all the production and safety parameters and characteristics of the Paks NPP are excellent on internationally accepted absolute scales. From this it follows that certain results of this research that may appear to be not so favorable – actually there are hardly any – can only be interpreted as relatively negative that still may well be quite positive on the relevant absolute scale.

The background and reference points of the research were the results of safety culture assessments completed in the period of 2000 – 2015.

The selected broad spectrum of methods has made possible to satisfactorily answer the research questions as follows.

- The general opinion of the employees about the usefulness of the SOL methodology in this NPP was definitely very positive: the big majority of all the respondents (employees who had already taken part in SOL event analyses, middle and top managers, instructors of the Training Center, anonymous employees who filled in the intranet-based questionnaires) considered the present SOL analysis practice as useful.

- The main added values of SOL analyses compared with the routine event investigation methodology as identified by the employees were
  - the SOL can identify organizational, leadership and procedure-related problems,
  - the SOL can take into account many aspects of events simultaneously,
  - the participants can get to know other professional areas and their representatives.

- The main beneficiaries of SOL analyses as identified by the employees were
  - the participants themselves,
  - wider professional areas,
  - directorates and the NPP as a whole(provided that the utilization of results will be improved).

- Almost all the respondents stated that the degree of the utilization of the results of SOL analyses is still not quite satisfactory. This is the relatively weakest point of the present application practice of the SOL. This result, however, at the same time set the course of improving the present practice by increasing the efficiency of utilization of the results.

- The bigger part of the opinions above markedly depended on the position and professional areas of the respondents.

In addition to these answers to the predefined research questions, we consider the many revealed finer details (not presented here) concerning the present SOL practice also as valuable results that support deeper understanding the organizational mechanisms and their interactions in this particular NPP.

Finally, since our basic hypothesis was that applying the SOL methodology appropriately increases the level of the safety culture, consider now the results of safety culture assessments. There is a clear coincidence of introducing the SOL in 2007 and the slightly, but continuously improving level of the safety culture from about 2010 (including the radical 10 % increase in the main index from 2013 to 2015).

Based on our empirical data presented in this paper it cannot be proven, of course, that there is a causal relationship behind this coincidence. However, it cannot be rejected either. We have good reasons to believe that introducing and continuously applying the SOL methodology in an appropriate way has been an important factor that has greatly contributed to improving the safety culture.

By the very nature of the NPP organizations all over the world – not considering here if it is good or not – efforts for keeping or increasing the level of safety culture are usually invested also in the frames of different safety campaigns. We are convinced that applying the SOL methodology correctly can also be regarded as a kind of effective and permanent – or at least long-lasting – safety culture campaign.

Acknowledgements

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