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Excellence in Operator Fundamentals at NEK

Matjaž Žvar
Nuklearna elektrarna Krško
Vrbina 12
8270 Krško, Slovenia
matjaz.zvar@nek.si

ABSTRACT

Operator fundamentals are defined as the essential knowledge, skills, behaviours and practices that individuals and operating crews need to apply to operate the plant effectively. The fundamentals that all operators should demonstrate are as follows: understanding of plant design and system interrelationships, monitoring plant indications and conditions closely, controlling plant evolutions precisely, approaching conservative to plant operations and having an effective teamwork.

The operator fundamentals are essential to prevent production losses or significant events to occur in nuclear power plants. The continuous usage of human error reduction tools and improvements in different processes are causing reliable and steady state operation of the power plants, preventing operators to gain experience and by so growing an excellent path to their knowledge loss, if training is not reinforced. This is a worldwide known degradation, also recognized by the World Association of Nuclear Operators – WANO, after events that have had happened worldwide in the industry.

At NEK we are coping in different ways of operations fundamentals monitoring to achieve excellency. We are gaining information from the as-found and from the as left simulator scenarios where the crews perform their job under different plant conditions – normal operation, during transients or emergency operation, under the supervision of their superiors and instructors. This data is then analysed and feedback is given to the operating crews and their superiors in different ways, also using performance indicators on operator competencies. But the main driver to achieve excellency in operator fundamentals is the active involvement of all participants – the operating crews, the operations management and the training department.

The paper describes the comprehensive processes established by the training department at NEK to prevent events related to operator fundamentals.

1 INTRODUCTION

Any training in any area tries to teach the participants how to do wright things in a right manner at the right time. But as simple as it is seen, in practice it is not always so easy to achieve, especially if complex evolutions are performed. The training should be very structured and it is usually also very time consuming, regardless of the training area: space, aviation, sport, nuclear, …

On January 15, 2009, the Airbus A320 serving the flight struck a flock of birds shortly after take-off from New York airport, losing all engine power. Unable to reach any airport for an emergency landing due to their low altitude, the pilots glided the plane to a ditching in the

Hudson River off Midtown Manhattan. [1] All 155 people on board were rescued by nearby boats, with only a few serious injuries. It was called the miracle at Hudson. But it wasn't any miracle.

The pilots did what they were trained for, they used their, in nuclear jargon, operator fundamental skills. They monitored their aircraft indications and conditions closely and identified insufficient thrust and engine restart capability to sustain flight. They controlled the aircraft evolutions precisely, wilfully and with intent. The plane was flown with a conservative bias, because they new they couldn't make to the airport, so the landing on the Hudson river water was made intentionally. To evaluate the situation and make decisions under great uncertainties, there had to be an effective teamwork between the pilots and the air traffic control workers. Solid fundamental understanding of the design engineering principles and sciences of flight and his plane capabilities made a successful landing in a bad situation. All operator fundamental postulates were used to cope with this event.

Operator Fundamentals are the essential knowledge, skills, behaviors, and practices that need to be applied by operating crews to operate the plant effectively [2]. Categories of operator fundamentals are as follows:

1. Monitoring plant indications and conditions closely - monitoring
2. Controlling plant evolutions precisely - control
3. Operating the plant with a conservative bias - conservatism
4. Working effectively as a team - teamwork
5. Having a solid understanding of plant design, engineering principles, and sciences - knowledge

The World Association of Nuclear Operators (WANO) unites every company and country in the world that has an operating commercial nuclear power plant to accomplish the highest levels of operational safety and reliability. This is achieved through a series of highly-regarded programmes, such as peer reviews, and access to technical support and a global library of operating experience.

It was recognized by WANO that industry efforts to improve operator fundamentals resulted in short-term reductions in the number of significant events and reactor trips caused or complicated by weaknesses in operator fundamental performance. However, these efforts were not sustainable, because the actions taken and lessons learned were not well incorporated into operational standards, training, and management systems. As a result, events caused by weaknesses in the use of operator fundamentals continue to occur too frequently.

2 IMPLEMENTATION OF OPERATOR FUNDAMENTALS IN TRAINING

Different methods are used to utilize/reinforce the fundamentals. Operations observations in the field and coaching while personnel performing evolutions, audits (internal or international organizations like WANO, IAEA), corrective action program used at NEK, industry experience, instructor reports, … But the most effective is the usage of the full scope simulator, were the crews show their performance under high fidelity conditions almost equal to the real working environment in the main control room, while performing evolutions under stress conditions.

Classroom training, on-the-job training, self-study and simulator demonstrations are also used for operator fundamental training, especially for the knowledge part. In this article the main focus will be on the simulator usage and the processes behind it.

2.1 How is the simulator training performed?

There are 6 shift crews operating the plant and 2 personnel crews not operating the plant, but with active licences. In one week, four of the operating crews are on duty, one crew is on training and one crew can use this time for vacation purposes. Each crew spend 140 effective hours on training per year – 80 hours on the simulator and 60 hours in the classroom. Those 140 hours are divided into 4 quarterly training segments. Shift crews exercise five days on the simulator for four hours a day.

The training week for each crew starts with an "As-found" scenario which is observed by Operations lead instructor and Operations superintendent or Operations manager. The very last simulator scenario is the exam scenario, where each shift crew is observed by the same observers as on the beginning of the week. At the end of both scenarios, lead instructor and operations observer give an overview to the crew, based on observed facts, of the scenario course and highlight operator's deviations from the expectations. In case of the "as-found scenario", this is an additional input to the scope of the training objectives for current week.

Each scenario consists of events that require the operators to demonstrate their knowledge of integrated plant operations, diagnose abnormal plant conditions, and demonstrate their ability to work together and to mitigate plant transients that exercise their knowledge and use of Abnormal Operating Procedures (AOPs) and Emergency Operating Procedures (EOPs).

Expectations related to scope of the training program are defined in NUREG-1021 Operator Licensing Examination Standards for Power Reactor [3] document, where the following Operator Competences and sub-competencies are listed below (in the brackets, corresponding operator fundamentals are stated):

1. Diagnosis of Events and Conditions Based on Signals or Readings (Monitoring)
   a) Recognize off-normal trends and status
   b) Use of information and reference material to aid in diagnosing and classifying events and conditions
   c) Correctly diagnose plant conditions based on control room indications
2. Understanding of Plant and System Responses (Knowledge)
   a) Locate and interpret control room indicators correctly and efficiently to ascertain and verify the status/operation of plant systems
   b) Demonstrate an understanding of the manner in which the plant, systems, and components operate, including setpoints, interlocks, and automatic actions
   c) Demonstrate an understanding of how their actions (or inaction) affected systems and plant conditions
3. Adherence to And Use of Procedures (Control, Knowledge)
   a) Refer to the appropriate procedures in a timely manner
   b) Correctly implement procedures, including following procedural steps in correct sequence, abiding by cautions and limitations, selecting correct paths on decision blocks, and transitioning between procedures when required
   c) Recognize AOP and EOP entry conditions and perform appropriate actions without the aid of references or other forms of assistance
   d) Recognize Limiting conditions for operation (LCO's) and correctly implementing those limitations

e) Recognize entry conditions for Emergency Preparedness (EIP) Implementation procedures and correctly implement the procedure steps.

4. Control Board Operations (Control, Conservatism)
   a) Locate controls efficiently and accurately
   b) Manipulate controls in an accurate and timely manner
   c) Take manual control of automatic functions, when appropriate
   d) Conservatism at monitoring and manipulating the reactivity
5. Crew Operations (Teamwork, Conservatism)
   a) Maintain a command role
   b) Provide timely, well planned directions to each other that facilitated their performance and demonstrated appropriate concern for the safety of the plant, staff, and public
   c) Maintain control during the scenario with an appropriate amount of direction and guidance from the crew's supervisors
   d) Use a team approach to problem solving and decision making by soliciting and incorporating relevant information from all crew member
6. Communications (Teamwork)
   a) Exchange complete and relevant information in a clear, accurate and attentive manner
   b) Keep key personnel outside the control room informed of plant status
   c) Ensure receipt of clear, easily understood communications from the crew and others

Each Operator competency has sub-competencies and each sub-competency is graded from 1 to 3. After each simulator scenario, a Simulator Crew Evaluation Form is completed by observers.

2.2 Collected data processing

At the end of each training segment Simulator Crew Evaluation Forms data for all shift crews are summarized into one document. The data consists of the numerical grading and a text explaining the deviation. The numerical grading is used to assess 22 sub-competencies (Figure 1) to give an integral overview on a training segment. The grades shown in figure 1 are the average values of all crews on a sub-competency.

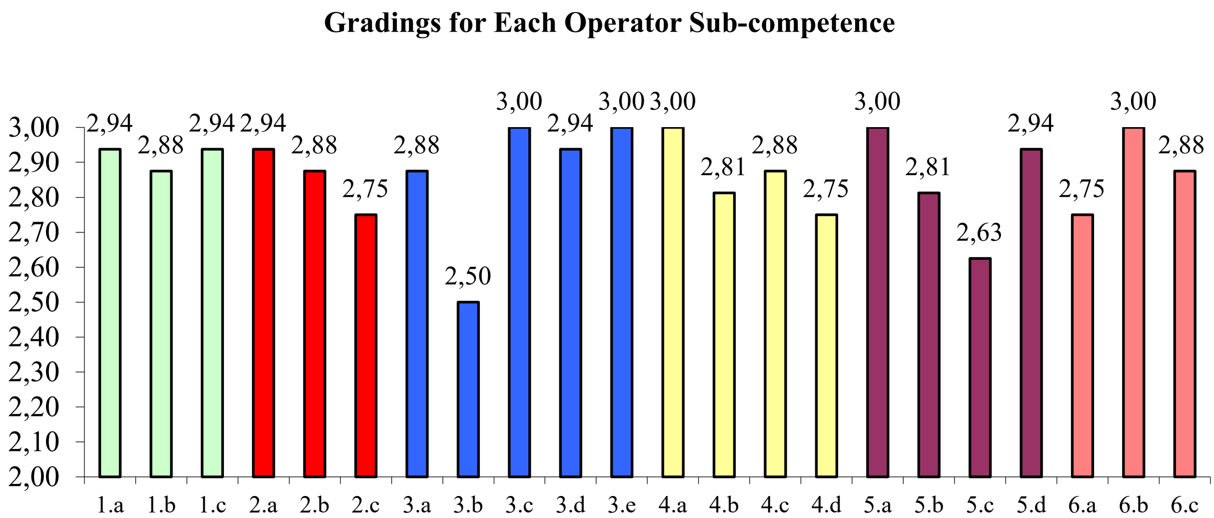

Figure 1: Gradings for sub-competencies

Those values are then trended in 22 different performance indicators on operator sub-competencies to present the entire perspective on crew performances. One example is shown in figure 2. As long as the trend is flat, there is no major decrease in the crew performance. If the trend is decreasing (black line) or if the grade (red dot) is below the green line, extra actions are taken to restore the performance in the next training segment. Examples are training segments 2019/2, 2020/1 and 2020/4.

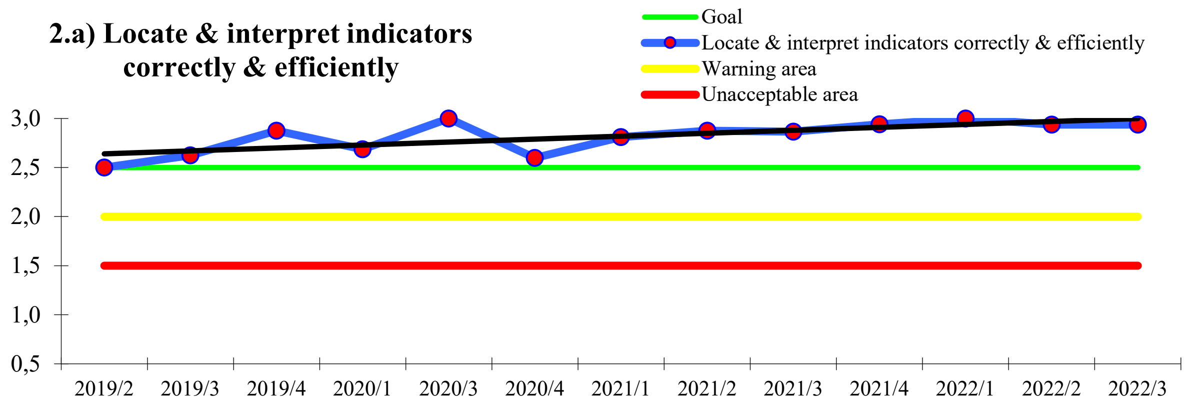

Figure 2: Example of a sub-competency performance indicator

The data is also used to grade each shift crew according to their performance. The grade is an average value of all 22 sub-competencies (Figure 3).

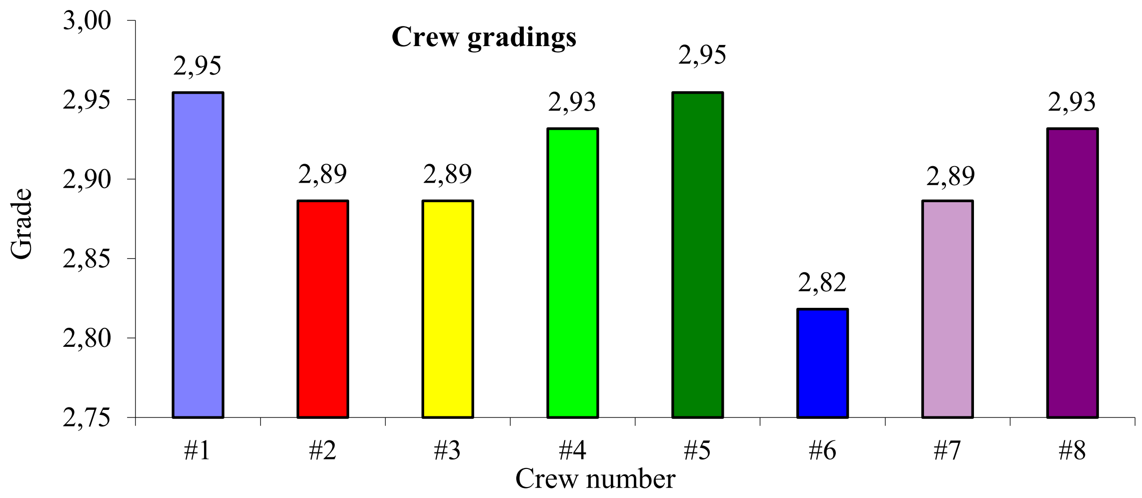

Figure 3: Integral grades for each crew

So far, we have assessed the crews on their performance which is based on NUREG 1021 Operator Licensing Examination Standards for Power Reactors, which was established by the U.S. Nuclear Regulatory Commission to establish the policies, procedures, and practices for examining licensees and applicants for reactor operator and senior reactor operator licenses at power reactor facilities. To receive the information on operator fundamentals, all performance comments have to be tagged on one of the five operator fundamentals area for each crew. This is done manually.

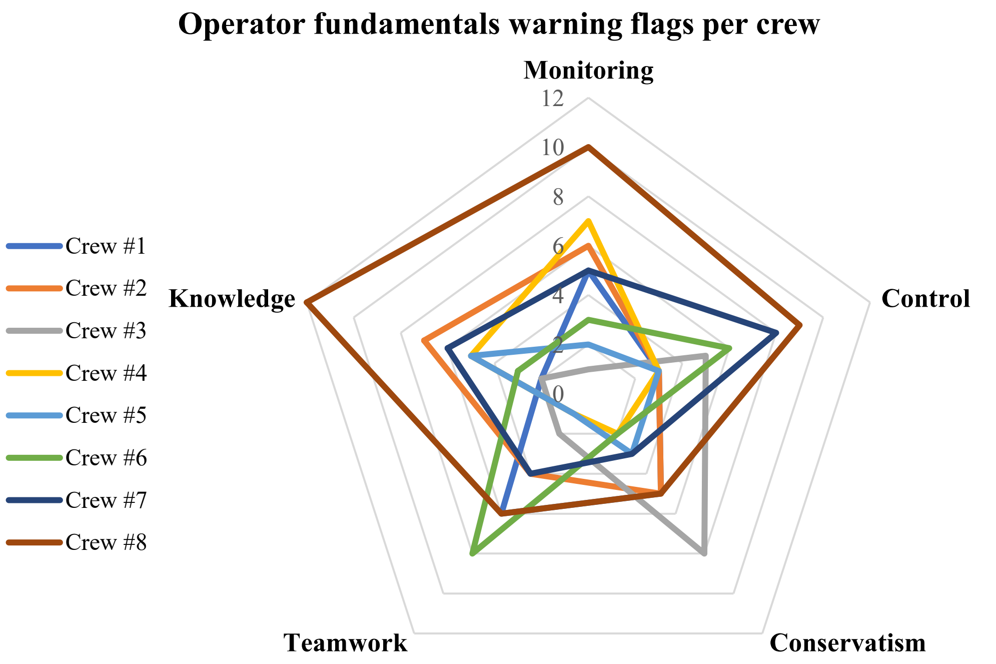

Figure 4: Operator warning flags per crew (no actual data)

The output is a radar chart showing warning flags for each crew on all operator fundamentals area on one training segment. (Figure 4). As it can be seen on the chart, an outstanding crew can be recognized immediately and so can also the deviating operator fundamental areas be.

2.3 Feedback – closing the loop

We have collected a lot of data during one training segment and this data has to be used effective and efficient – we have to close the loop. In this loop, all crews, instructors and the operations management are involved. And written report is issued at the end. After collecting and analysing data, decisions have to be made on what remedial actions need to be taken or implemented. This is done in several steps.

At the end of each training segment, the results are evaluated and discussed among the instructors and remedial actions are proposed to improve deviating areas. It can be seen on the PI's after the next training segment, if the proposed actions were appropriate.

The operation management is also involved in training in more ways, they participate on the "as-found" and "as-left" scenarios, they perform lectures for the crews and they participate in the Operations training oversight committee, where their training is managed and remedial actions approved or proposed.

The crews are getting feedback of their performance in two ways, immediate after the two evaluating scenarios on the simulator and a delayed integrated feedback in the classroom at their consecutive training segment. The immediate feedback is given from the operations management and from the operations training supervisor right after freezing the simulator. The delayed feedback is comprehensive and is given in an hour classroom session from the operations training supervisor.

The feedback is performed systematically, it includes all recognized facts from all crew´s evaluations during the previous training segment and the focus is on the worst sub-competency grades and their associated PI's to include the history for recognizing any deeper issues. According to figure 1, those would be 2.c, 3.b, 4.d, 5.c and 6.a. For those sub-competencies, all written facts during the evaluations are discussed in detail with the crew and put in context. Immediately after the simulator evaluation, the crew received the feedback on their own deviations from the standards, in the classroom they receive a comprehensive integrated feedback on deviations on sub-competencies from all crews. This is also the place where they receive feedback on operator fundamental areas (Figure 4.).

3 CONCLUSION

At the end, how do we know that we have succeeded? Have we prevented errors to occur? To answer that, two performance indicators on plant level, are indirectly showing the status of operator fundamentals.

The first performance indicator is named Operations Human Performance Events (figure 5). The indicator purpose is to monitor operational weaknesses and practices that require more attention and call for improvements. The indicator is defined as the sum of all events induced by operating crew's errors in an observed period. It is based on human performance, but it is corelated to 4 of the operator fundamental parameters – monitoring, control, conservatism and teamwork. In 36 months, we have had 12 events corelated to operator fundamentals, in average 1 event per 3 months. Given the large number of daily activities in the main control room, this is really a low number. The majority of events occurred during the 2019 outage (4/2019), the next outage in April 2021 (2/2021) took place without events. In outage 2019 there were 35.720 activities going on in 28 days with more than 2000 workers participating in it.

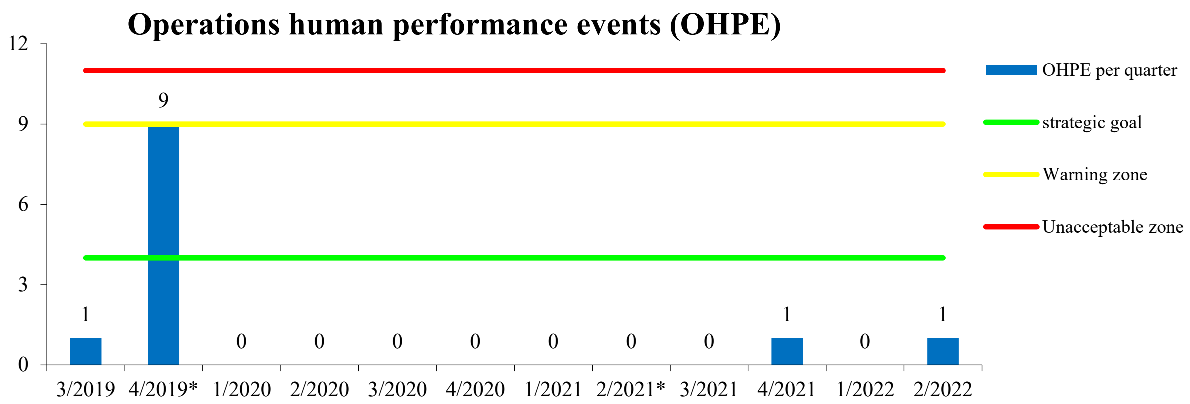

Figure 5: Operator human performance events

The second performance indicator Number of events due to training deficiency at plant level (figure 6). The indicator monitors number of related events due to training deficiencies, which provides basis for evaluation of plant safety and overall culture of operation. The indicator considers events recorded in the plant Corrective Action Program. This PI can be corelated to knowledge. In the last 5 years there were 10 events related to training deficiencies due to different causes, but none of them were related to operator knowledge. 4 of the events were caused by contractors performing activities at the plant.

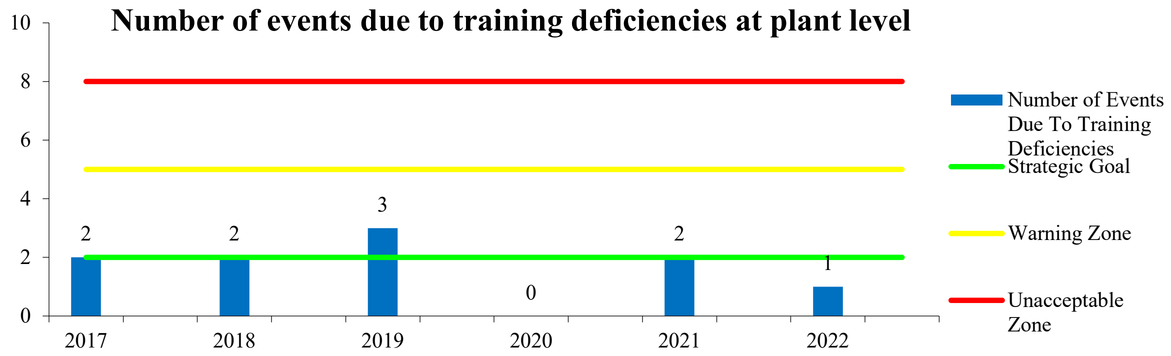

Figure 6: Number of events due to training deficiencies at plant level

In the training process, all 4 levels of Kirkpatrick´s evaluation model are included, reaction, learning, behaviour and results [4]. According to the results from the PI's, even though they are good, there still are areas for improvement. Especially in the contractor training area, which is not part of this article's research. The long-term goal is an event free operation. The processes established at the plant are leading us towards that goal in small steps. At the end, the time will tell, if we have succeeded.

4 REFERENCES

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