How many lives did you save in today's HAZOP?

Using data analytics and the DEKRA Dynamic Risk Register to figure it out

White Paper DEKRA Advisory & Training

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Dynamic Risk Register

If you cannot measure it, **it does not exist**

„When you can measure what you are speaking about, and express it in numbers, you know something about it. When you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts advanced to the stage of science.“

William Thomson, 1st Baron Kelvin

We could summarize the above quote by Lord Kelvin as "if you cannot measure it, it does not exist". In light of this scientific premise, the process safety community has developed a number of methodologies to measure risk. This white paper examines how structured and systematic **Process Hazard Analysis (PHAs)**, and specifically **Hazard and Operability Studies (HAZOP)** save lives, and we offer a mathematical estimate of how many.

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HAZOP:
The method of choice

A qualitative method at its core, HAZOP has adapted semi-quantitative measurements to become the method of choice in most cases. Semi-quantitative HAZOP uses a risk matrix plotting both the severity and likelihood of issues to assess every defined scenario that could affect an asset or process. Figure 1 shows a risk matrix example taken from the DEKRA HAZOP procedure.

Implementing pre-defined independent scales, analysts rate hazards posed to people, the environment and company assets as well as the probability of an incident occurring. A textual description of each category is usually provided to support discussion team rankings.

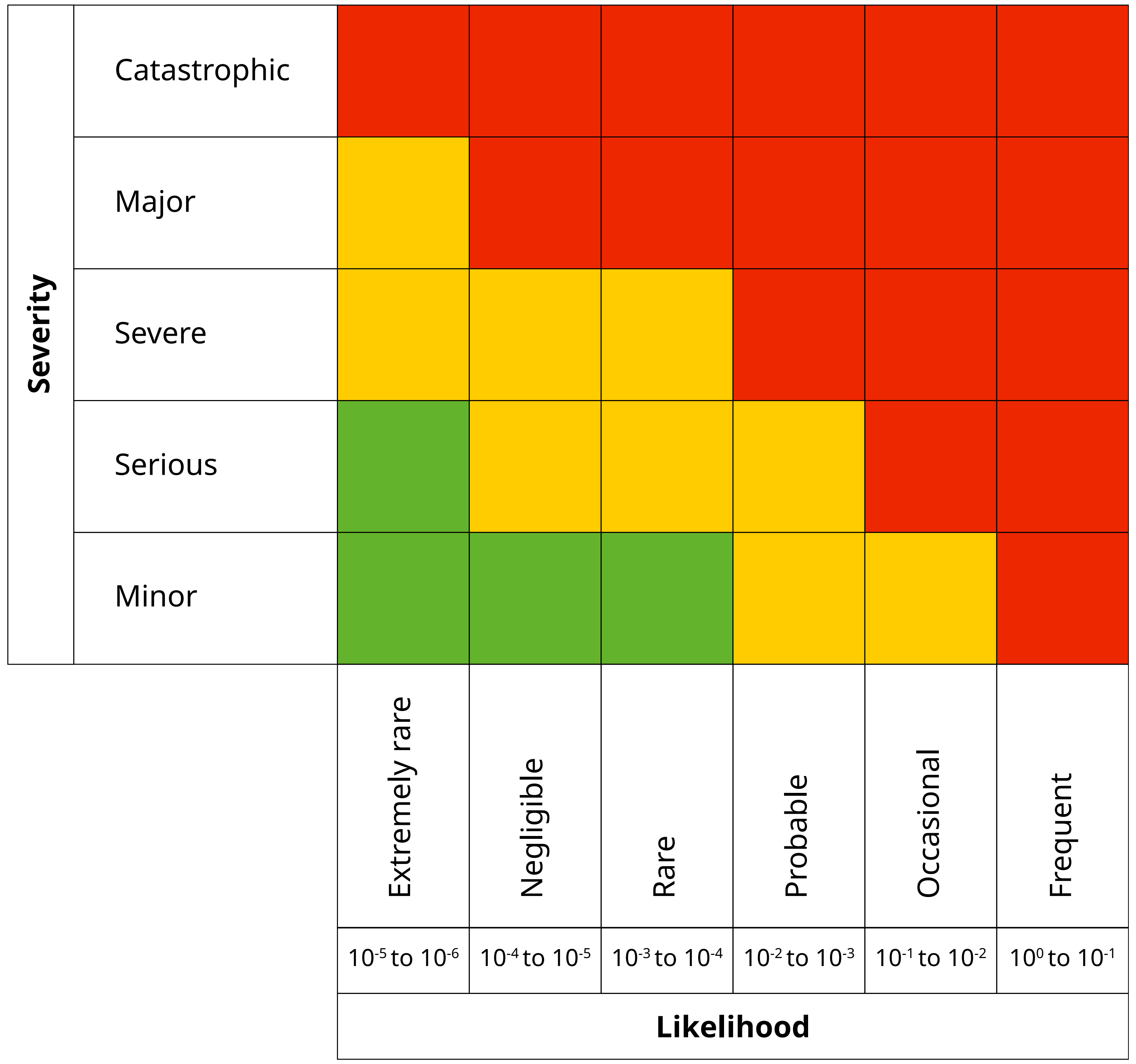

Figure 1. Example of a risk matrix used in a HAZOP

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Managing information **collected during HAZOP**

Requiring a multi-disciplinary team of experienced personnel dedicated often for weeks to brainstorming hypotheses of what could go wrong and just how wrong things could go, HAZOP can be a rather lengthy, expensive exercise. HAZOP collects a wealth of data on each asset, process and potential risk which is then compiled into tables sometimes spanning hundreds of pages and thousands of scenarios.

It is extremely difficult to manually extract, from such huge volumes of data, the pertinent information needed to answer useful operational questions determining, for instance

- The contribution a single, specific safeguard makes to risk reduction.
- The plant risk condition with one safeguard out of service (maintenance, calibration).
- The percentage of risk stemming from different types of causes, like human error, equipment failures or external events.
- The total risk reduction provided by different categories of safeguards, like administrative procedures or process interlocks.
- How a plant risk map compares with peer plants (type, technology, geographical location).

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Our clients spend huge quantities of resources including time, efforts and money to conduct life-saving HAZOP procedures compiling a vast overview of all elements of risk pertaining to company assets and operational processes. Instead of leaving the HAZOP results dormant on a server or shelf, the DEKRA Dynamic Risk Register (DRR) extracts information to provide useful data analytics that can be accessed to answer questions when making critical daily decisions.

While HAZOP provides an important still picture of a facility, a real, operating plant is anything but inactive. The DEKRA DRR is dynamic, using the input of slight daily changes such as equipment being out of service for maintenance, instruments disassembled for calibration or even a failed pump to recalculate an updated, real-time risk condition of the plant.

Developed to extract relevant information from process hazard analysis (PHA) data, the DEKRA Dynamic Risk Register can be used in both traditional and new-generation **Digital PHA** formats. DRR computes a host of scenario-driven statistics related to causes, consequences, risks and safeguards which are then depicted in various easy-to-understand charts and tables.

Figure 2. Risk map, compared with a benchmark cluster of plants.

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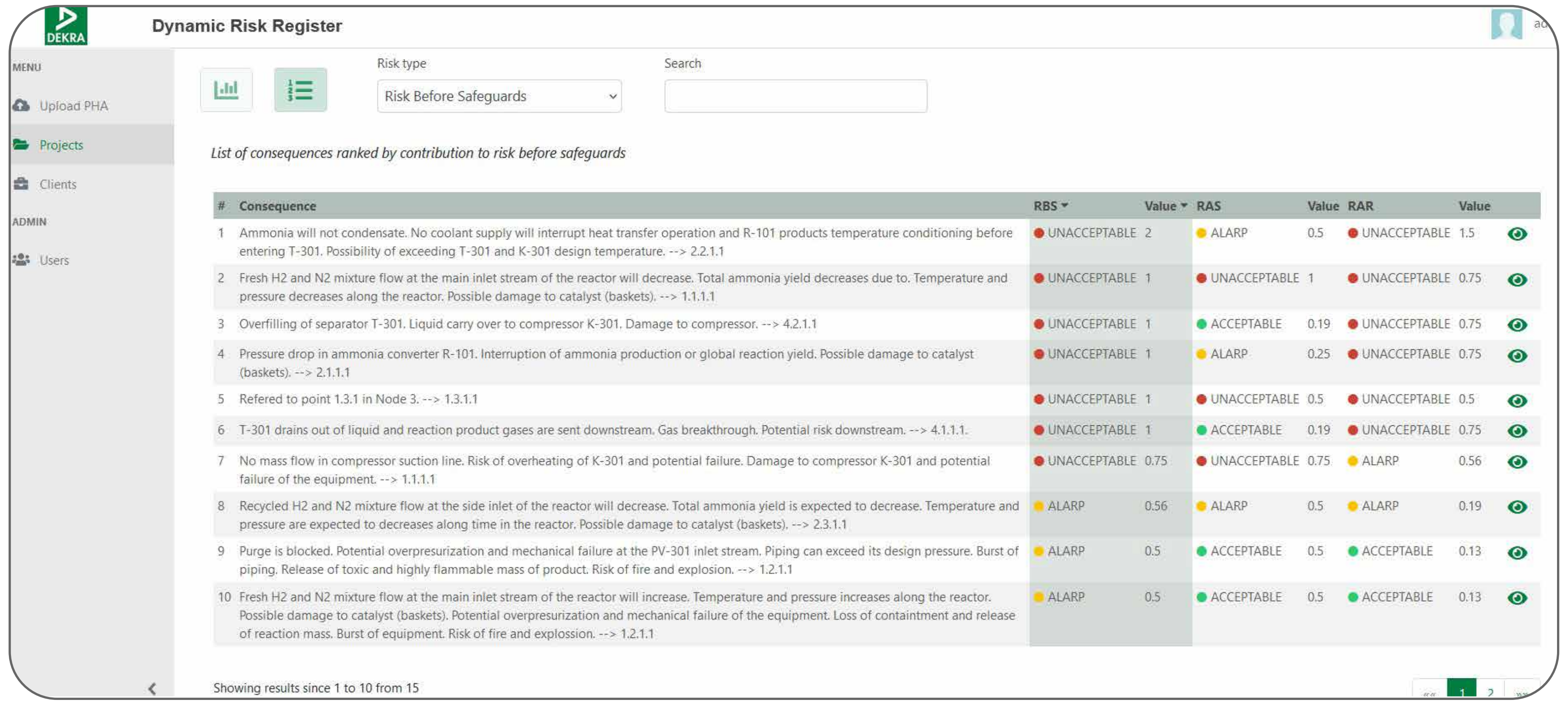
In further efforts to provide a user-friendly interface, the DRR can be used to lay color-coded consequence or risk levels over typical engineering diagrams and layout drawings for quick and easy reference. Each diagram is linked to the list of relevant scenarios for every piece of equipment shown for easy access to information.



#	Consequence	RBS	Value	RAS	Value	RAR	Value
1	Ammonia will not condensate. No coolant supply will interrupt heat transfer operation and R-101 products temperature conditioning before entering T-301. Possibility of exceeding T-301 and K-301 design temperature. --> 2.2.1.1	UNACCEPTABLE	2	ALARP	0.5	UNACCEPTABLE	1.5
2	Fresh H2 and N2 mixture flow at the main inlet stream of the reactor will decrease. Total ammonia yield decreases due to. Temperature and pressure decreases along the reactor. Possible damage to catalyst (baskets). --> 1.1.1.1	UNACCEPTABLE	1	UNACCEPTABLE	1	UNACCEPTABLE	0.75
3	Overfilling of separator T-301. Liquid carry over to compressor K-301. Damage to compressor. --> 4.2.1.1	UNACCEPTABLE	1	ACCEPTABLE	0.19	UNACCEPTABLE	0.75
4	Pressure drop in ammonia converter R-101. Interruption of ammonia production or global reaction yield. Possible damage to catalyst (baskets). --> 2.1.1.1	UNACCEPTABLE	1	ALARP	0.25	UNACCEPTABLE	0.75
5	Refered to point 1.3.1 in Node 3. --> 1.3.1.1	UNACCEPTABLE	1	UNACCEPTABLE	0.5	UNACCEPTABLE	0.5
6	T-301 drains out of liquid and reaction product gases are sent downstream. Gas breakthrough. Potential risk downstream. --> 4.1.1.1.	UNACCEPTABLE	1	ACCEPTABLE	0.19	UNACCEPTABLE	0.75
7	No mass flow in compressor suction line. Risk of overheating of K-301 and potential failure. Damage to compressor K-301 and potential failure of the equipment. --> 1.1.1.1	UNACCEPTABLE	0.75	UNACCEPTABLE	0.75	ALARP	0.56
8	Recycled H2 and N2 mixture flow at the side inlet of the reactor will decrease. Total ammonia yield is expected to decrease. Temperature and pressure are expected to decreases along time in the reactor. Possible damage to catalyst (baskets). --> 2.3.1.1	ALARP	0.56	ALARP	0.5	ALARP	0.19
9	Purge is blocked. Potential overpresurization and mechanical failure at the PV-301 inlet stream. Piping can exceed its design pressure. Burst of piping. Release of toxic and highly flammable mass of product. Risk of fire and explosion. --> 1.2.1.1	ALARP	0.5	ACCEPTABLE	0.5	ACCEPTABLE	0.13
10	Fresh H2 and N2 mixture flow at the main inlet stream of the reactor will increase. Temperature and pressure increases along the reactor. Possible damage to catalyst (baskets). Potential overpresurization and mechanical failure of the equipment. Loss of containtment and release of reaction mass. Burst of equipment. Risk of fire and explosion. --> 1.2.1.1	ALARP	0.5	ACCEPTABLE	0.5	ACCEPTABLE	0.13

Figure 3. Ranked list of consequences.

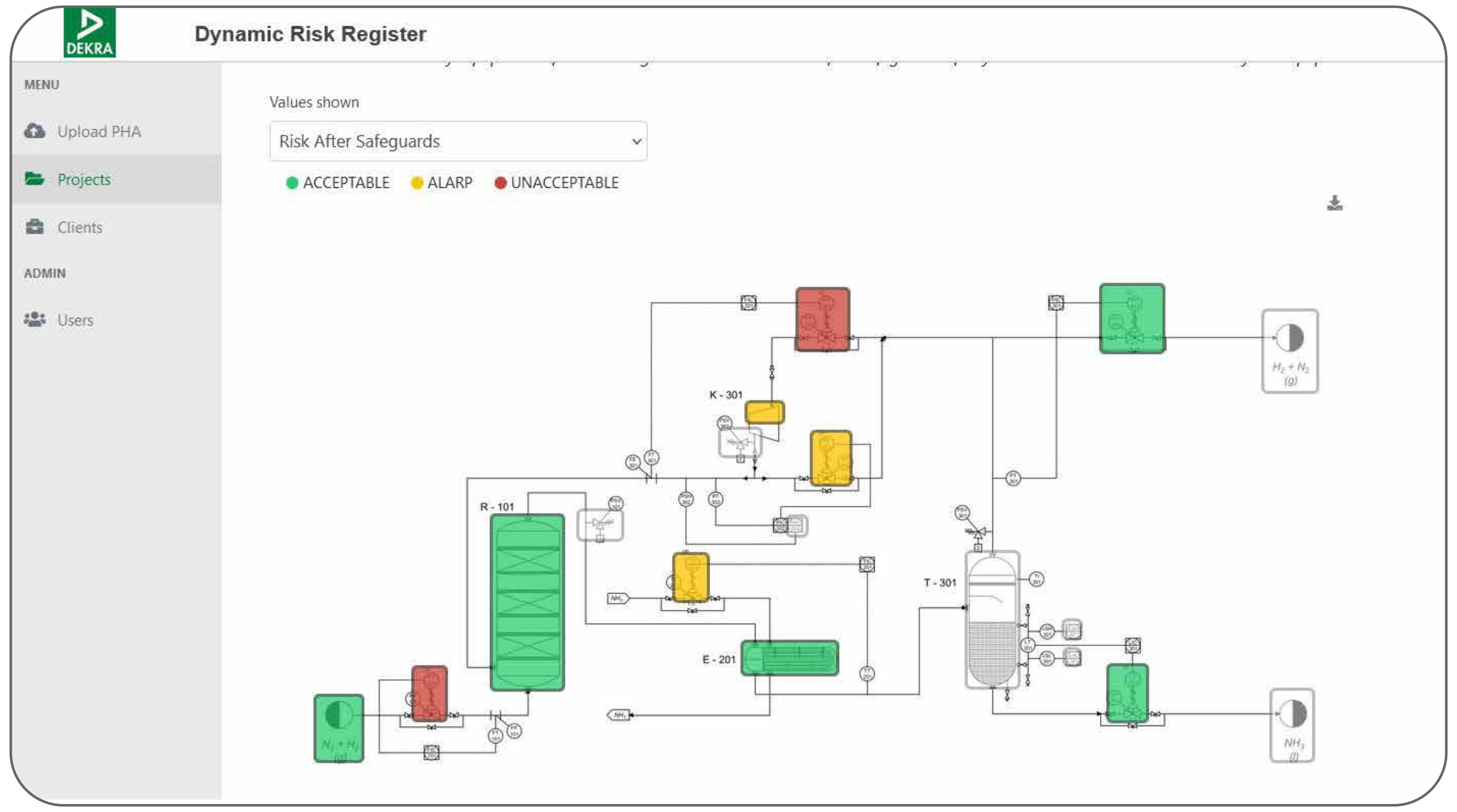


Figure 4. Risk after safeguards shown on a process and instrumentation diagram.

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So, **how many lives** did you save today?

Returning to the question posed in the title of this paper, it becomes evident that a HAZOP, by itself, does not inherently reduce any risks. The reduction of risks for an industrial asset or process stems from the actual implementation of the recommendations provided by the HAZOP team. Still, a HAZOP contains the information required to provide an answer to our question. Once again, analyzing a HAZOP manually is a cumbersome task, but the DEKRA Dynamic Risk Register provides data analytics to make that process easier.

Depending on the initial risk of the plant or process, the HAZOP team issues recommendations until reaching a "green cell" on the risk matrix. When starting from high risk, the team needs to provide a larger risk reduction, whereas less risk reduction is needed when starting from a lower risk. If all scenarios are tolerable with existing safeguards, no recommendations are necessary, and the risk reduction is null. Therefore, our first conclusion is that the risk reduction provided by a HAZOP depends on the initial risk of the process.

After running a sample of HAZOPs facilitated by DEKRA experts in the past through the Dynamic Risk Register, we calculated that the number of lives saved over the asset's life cycle ranges from 0.003 to 8 per day of HAZOP. That is, in a very risky process, 8 future fatalities were avoided for every day of HAZOP. The average of our sample was 2.7 lives saved per day of HAZOP.

Deepening our analysis a bit, we determined relative risk reduction to be a more constant parameter. Relative risk reduction is therefore defined as the final risk divided by the initial risk:

$$\text{Relative risk reduction} = \frac{\text{Risk before recommendations} - \text{Risk after recommendations}}{\text{Risk before recommendations}}$$

Using this definition, we found that relative risk in our sample had been reduced by a whopping 3.7% per HAZOP day.

Process safety plays a key role in every industrial and business sector around the globe. Protecting personnel safety, company assets, environmental integrity and the well-being of the communities in which you operate relies on effective risk management and process safety throughout your business. So, in the end, your commitment to process hazard analysis really does determine how many lives you can save over the lifetime of your particular asset.

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Main **takeaways**

- Having facilitated hundreds of Process Hazard Analysis since the mid-80s, our DEKRA experts advise clients that PHA is extremely powerful yet expensive in terms of resources that the company must commit. However, when you recognize that every day using HAZOP can save an average of almost three lives over the asset lifecycle, you start to see things in a different perspective.

- Organizations often perform Process Hazard Analysis during the design phase of a new asset and review them when planning major changes. In the best cases, PHA is also conducted periodically to account for creeping changes. However, organizations rarely use PHA as a daily operational decision-making tool despite the resources that have been commited.

- Advanced digital solutions such as the Dynamic Risk Register can revitalize and transform Process Hazard Analysis into true decision-making tool.

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The foundation of any safe and sustainable work environment is built on prudent process safety policies and practices. Our cross-industry training and advisory services educate and advise to help you understand and reduce risk. To that end, we are leveraging digitalization to enhance process safety, including obtaining accurate advice for hazard identification and risk prediction, utilizing digital technologies for training and competence development, and replacing physical material testing with digital equivalents.

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