How to Improve the Trust in Safety Related Instruments

Wolter Last*
Hint Americas Inc.
2800 Post Oak Boulevard, Suite 4100
TX 77056, Houston
*Presenter E-mail: wlast@hint-global.com

Abstract

Yearly Instrument Protective Functions (IPF) reports for safety critical elements are common practice in the oil and gas and petrochemical industry. Including mean time between failures (MTBF) calculations and fail to danger/ fail to safe evaluations, they give an overview about the integrity of the installed based instruments and help to define eventual engineering adjustments. However, input information for the IPF reports are often manually entered on paper or in excel sheets which is inefficient, costly and subject to human errors. Plants sometimes cannot retrieve or store the instrument data because the infrastructure is not there to connect to directly.

The method of monitoring process safety and fire & gas instrument within the oil and gas and petrochemical industry needs to evolve. Operators need to be able to trust their instruments and rely on actual, accurate and controlled real-time data.

What if the process safety instrument data were automatically entered in a process safety maintenance management system? IPF reports could be customized and generated any time, instrument maintenance activities could be triggered by predefined conditions, etc. The possibilities are extensive.

By using an automatic process safety maintenance management system, the reliability of safety related instrument can be improved, company risks can be reduced, and the efficiency of testing and can be increased.

Keywords: Instrument Integrity, Risk Reduction, Process Safety Management System, Instrument Protective Functions, Condition Based Maintenance, Safety Integrity level (SIL).

1 Introduction

Nowadays it is uncommon to wait an extensive period to receive results. If you must wait a week for medical results, you start questioning why it is taking that long. Yet in some parts of the

industry it is still acceptable to have yearly intervention moments, instead of real time observation. Instrument Protective Functions (IPF) reports are usually done on a 6- or 12-month schedule. These reports provide results on the reliability of the process safety related instrument. In worst case scenario it would be possible to have a poor performing process safety instrument of nearly a year. Would you trust a doctor that lets you wait months for results?

Process safety reporting should be required by law to obtain and keep the license to operate. There are international standards like: IEC 61511, API, ISA and legislations which outline the requirements to obtain a license to operate. If these requirements are not met, the plant is not permitted to operate. These laws and legislations set a base level of trust in the operations of a plant.

Safety related instruments are the principal contributors to possible failures of most protective functions as shown in below graphic taken from a major oil company's 2017 IPF report.

FTD per loop item 2017
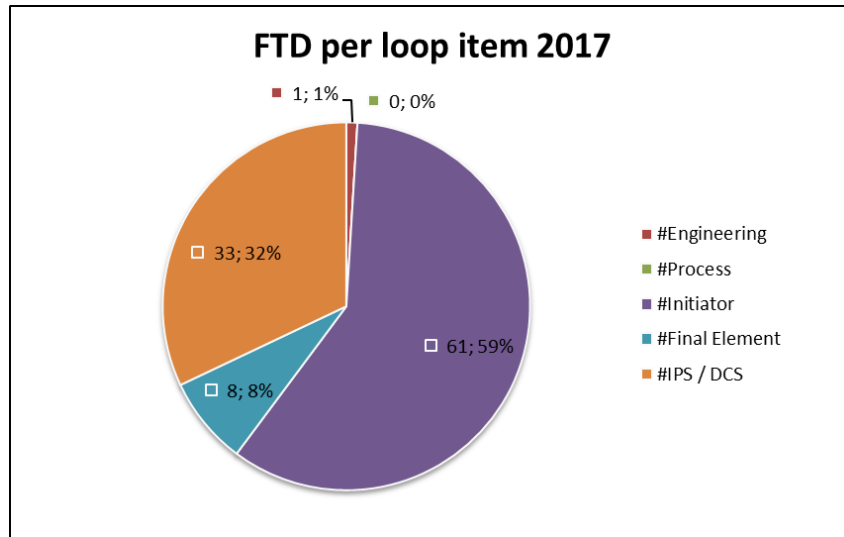
For this example, the field instruments (initiators + final elements) are responsible for a 70% of the Failure To Danger (FTD's). This means that engineering and maintenance effort should concentrate on the field instruments.

Instruments are evolving from simple 4-20 milliamp transmitters into smart instruments, which don't only transmit the reading, but are also capable of sharing health status information. Example of instruments are temperature, pressure, level transmitters, process safety valves, fire, smoke and gas detectors etc. Testing/validation/calibration can even be done automatically. Yet in IPF reporting it is still common to do manual validations. While doing these validations, the results are written down on paper or in more advance cases logged into a handheld. This process is time consuming and error prone. Within the industry the biggest margin of errors is caused by humans. With the capabilities of smart instrument this process can be automated. The validations from the field can immediately be stored into a database, preventing the human errors in the process.

Manual validations require a person to be present while the validation runs, to observe the results. When using instrument automated validations, the presence of a person is not needed and can be executed remotely. This would mean that 1 person could start multiple validations at the same time and have the results be stored automatically, which saves significant amounts of time.

Being able to remotely trigger the validations can improve the time efficiency even further. Smart instrument can handle remote triggers to start their validations. Considering the process, there is the potential to initiate validations on all the instrument at the same time. A process safety maintenance management system could schedule these triggers and could for example run monthly validation and calculate Key Performance Indictors (KPI's) like Mean time between failure, fail to safe (FTS), fail to danger (FTD), fail to nuisance (FTN), availability rate, etc. If a process safety related instrument is not performing within the process safety criteria they must be replaced.

The logic to determine if a piece of instrument is running correctly can be executed automatically when a new validation result is received. Combining automated judgement with automated scheduled validations would provide insight on the recurrence of the validations and provide way more accurate insight of the performance of the safety related instrument.

Human interaction is needed when validations fail. When validations fail, maintenance is needed to correct or replace the safety instrument. An example of maintenance would be to calibrate a process safety related pressure transmitter to make sure the validations are within expected ranges and that the instrument is working safely with other words e.g. if the pressure comes above HPA the safety system should act accordingly and close the valve.

Live process and diagnostic data create further opportunities to observe and maintain the safety instrument. An experienced technician can judge whether instrument needs maintenance. For example, reading will drop if a filter starts getting plugged. Based on the information retrievable from smart instrument and the experience from technicians, triggers can be designed which indicate when maintenance needs to be done and more specifically which maintenance needs to be done. The maintenance is then instead of corrective or preventive, based on conditions.

2 Trust factors

What determines if a safety related instrument is trustworthy?

- Acts according to designed safety criteria
- Results of gathered data
- Amount of gathered data
- Quality of gathered data
- Method of gathered data

- Frequency of gathered data

- Performance indicators

- Cross comparison

Is a result within its limits trustworthy when a fault signal is active on the instrument? When you have a complex system, is one sample enough to validate the system? Would you rather trust a validation ran in the field over a validation in a controlled laboratory? These questions seem simple but are questions we do not always keep in mind when executing routine tasks. To improve the trust in safety related instruments the correct answers need to be given for these questions every single time.
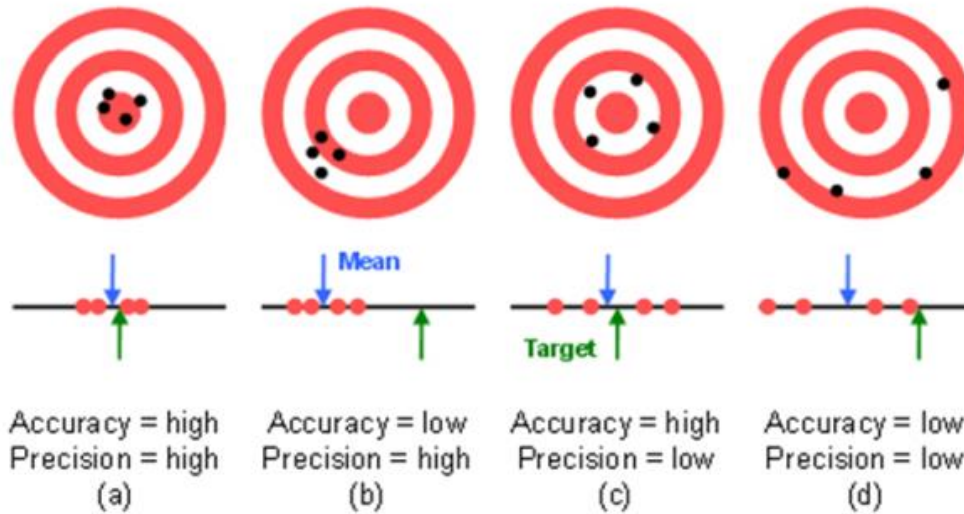
4 Design

The first and most important part of process safety instruments is if they act according to the design. When a limit is reached an action needs to be taken e.g. set of the sprinkler system, shut a valve or ring the alarm. When doing validations, it is being checked if an instrument runs correctly, but the fail scenario is not continuously tested if an instrument runs correctly. In normal operations these scenarios should be avoided, but when the opportunity is there to test the fail scenarios, it is important to make sure that all systems respond the way they should in case of an emergency.

5 Results

Results are the basis to proof the trustworthiness of an instrument. When the results go out of the preconfigured bounds for a safety instrument an action needs to happen. An alarm needs to be rang in case of a gas detector and a sprinkler system needs to activate in case of an office fire. These systems are to ensure the safety of the people and resources in a certain area and within the industry it safeguard the process operation. It is however very costly when the sprinkler system is triggered incorrectly and destroys all electrical instrument like computers and ruins all documentation. This is the reason why generally for firefighting system initially only an alarm is ringing, and sprinklers are not automatically engaged in an office area. The reason is the risk involved with the potential danger that the office fire has to the people and resources in that moment and place.

6 Amount

Amount of results of an instrument provide information about the precision and accuracy. This information only becomes available when you compare measuring results to previous results. It is comparable to shooting with bow and arrow. one single shot tells you something about your accuracy. It does not give you any information about your precisions, because there is nothing to compare it to. Conclusions can be drawn after a couple of shots:

Accuracy = high Precision = high (a) Accuracy = low Precision = high (b) Accuracy = high Precision = low (c) Accuracy = low Precision = low (d)

These extra results provide valuable information which otherwise would not have been considered when only looking at one validation. This extra information can detect if there is a failure upcoming, for example through trend checking.

7 Quality

One value by itself often does not tell you the full story of an instrument. For simple analysers there is often a flow switch or some extra signal to tell you that the value is trustworthy. The more complex the instrument is the more information it can provide about its trustworthiness. Combine that extra information with the results gathered in the chapter amount and a system can produce a quality label to inform the investigator about the quality of the instrument at the time of doing a validation. This quality label provides extra insurance that the data received from the instrument is correct.

8 Method

There are different ways and methods to run instrument validations. For analyzers there are reference sample tests, line sample tests etc. and for valves there are bump tests and leak tests. The biggest difference in these options is the amount of human involvement. Systems do not change procedures or execute them partly. Humans do have the tension to change things especially when pressed for time or with a lack of motivation. This inconsistency is a big risk for data gathering. An instrument measuring a value is a process which can be controlled and improved. The process of reading a value and writing it into a system by a human cannot be controlled. Human errors cover a large portion of the errors in our industry and can be prevented. Humans don't like to do the same task repeatedly, even it is their job. Therefore, automated data gathering is preferred over manual data gathering. It reduces costs, it reduces the change of errors, it creates opportunities of gathering more data and created instant evaluations and notifications or alarms. The human can then use all this extra information to judge where actions are needed to correct the instrument and make sure everyone stays safe.

9 Frequency

The importance of frequency can be explained by an example of a bowl or marbles. In case you have two marbles, the chance of picking the yellow marble is 50 precents. Given that the picked marble is put back the second time the chance of getting the yellow marble is 75 precents and the third time 87,5 precents etc. When the bowl of marble contains more marble, the chance is significantly reduced for picking the fellow marble.

1
sample:

50%

2
samples:

75%

3
samples:

87,5%

4
samples:

93,8%
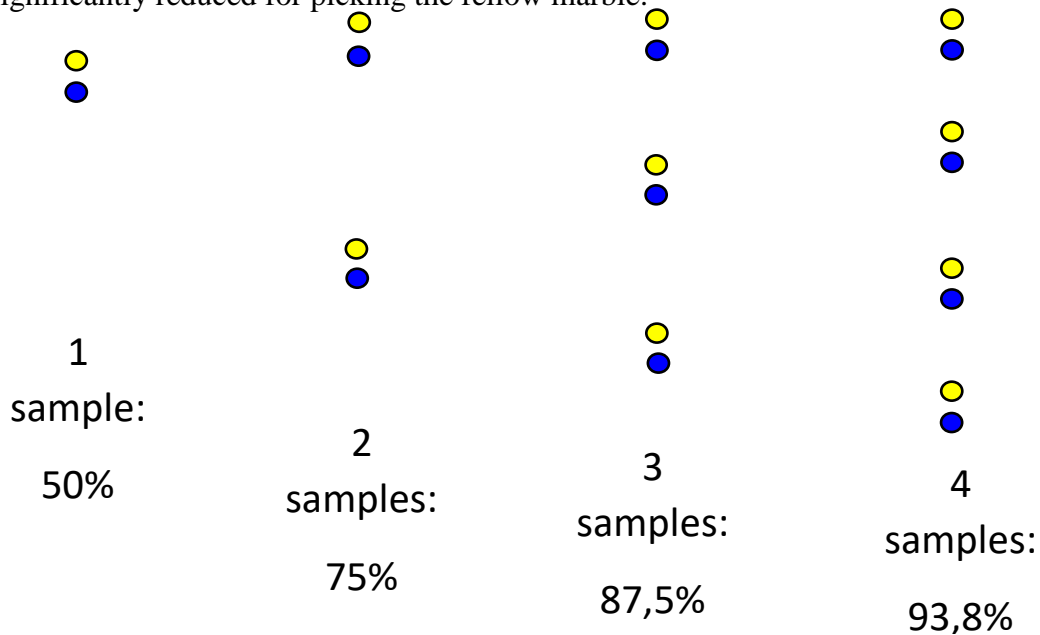
The important questions is how confident do you want to be to catch the error or how much assurance do you want that there is no error in the instrument. The more complex the system, the more validations need to be done to ensure that the instrument is trustworthy.

		Marble count				
		2	5	10	50	100
	1	50,00	20,00	10,00	2,00	1,00
	2	75,00	36,00	19,00	3,96	1,99
	3	87,50	48,80	27,10	5,88	2,97
	4	93,75	59,04	34,39	7,76	3,94
	5	96,88	67,23	40,95	9,61	4,90
	6	98,44	73,79	46,86	11,42	5,85
	7	99,22	79,03	52,17	13,19	6,79
	8	99,61	83,22	56,95	14,92	7,73
	9	99,80	86,58	61,26	16,63	8,65
	10	99,90	89,26	65,13	18,29	9,56
	20	100,00	98,85	87,84	33,24	18,21
	30	100,00	99,88	95,76	45,45	26,03
	40	100,00	99,99	98,52	55,43	33,10
	50	100,00	100,00	99,48	63,58	39,50
	60	100,00	100,00	99,82	70,24	45,28
	70	100,00	100,00	99,94	75,69	50,52
Sample count	80	100,00	100,00	99,98	80,14	55,25
	90	100,00	100,00	99,99	83,77	59,53
	100	100,00	100,00	100,00	86,74	63,40

8 Performance indicators

Another important aspect of the quality label is the performance indicators. Performance indicators can be calculated when then state of an instrument is being recorded. Possible states are utilised, maintenance, faulted and out of service (offline). Calculations that can be made based on those

states are mean time between failure, mean time to repair etc. These calculations can be used as a basis for the quality label mentioned in chapter 5.

10 Cross comparison

Instruments can be cross checked to further increase the trust in an instrument. Cross referencing becomes easy when all the data is stored in a database and available through an easy to use application. With cross referencing anomalies can be found like the temperature difference of night and day.

11 Conclusion

The full data spectrum of a process safety related instrument needs attention to gain trust and improve reliability.

1. Make sure the design SIL level is correct and that the instrument still acts accordingly.
2. Verify the instrument by running validations, preferably automatically.
3. Gather enough information to make sure there are no decisions made on random results.
4. Check multiple aspects of the instrument to ensure data quality.
5. Choose the correct method for the validation for quality and efficiency.
6. Plan the frequency of validations based on the complexity of the instrument.
7. Use performance indicators to watch the performance of an instrument.
8. Conduct cross comparisons to find additional improvements.

The goal is to go from paper file to electronic data. Not only the current validation, but also track the history of previous validations. The system stores information of all safety critical instruments like Availability, reliability, MTBF, FTD, FTS, etc. during the life cycle of the installation. Having a real-time system and relational database available which can generate reports of all safety critical instruments instantly. Company risk will be reduced by having a transparent system in place where the evidence is gathered and stored for all safety related instruments and prove that they are performing within the expected design criteria.

Through automation the efficiency of maintaining safety related instruments can be improved, which creates time to look further into the instrument data to further improve the performance and trust in the instruments.