EUROPEAN PROCESS
SAFETY CENTRE

Alarm Management

eni

San Donato Milanese – Italy; 31 August, 2021
NUREDDIN MILAD, TUV FSE ENGINEER, eni

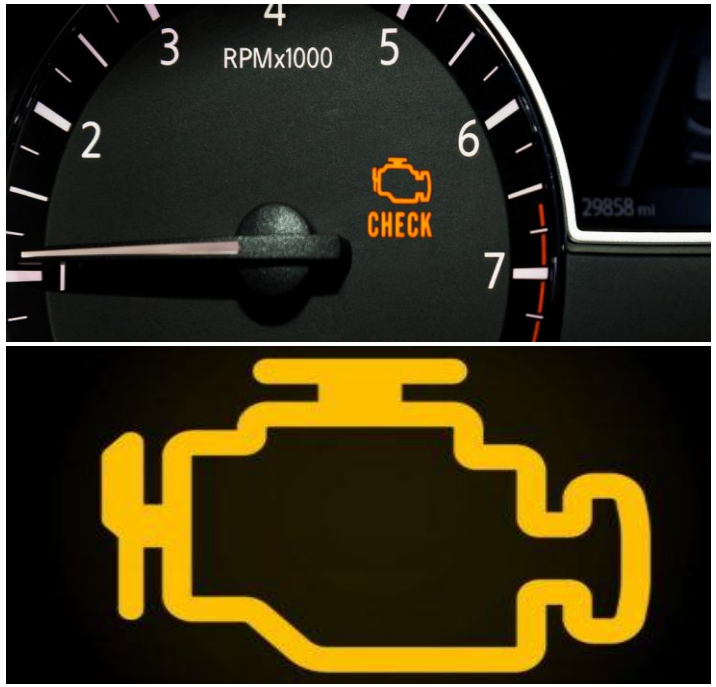
Introduction

Just Imagine that while you are driving to work, each minute an alarm goes off:

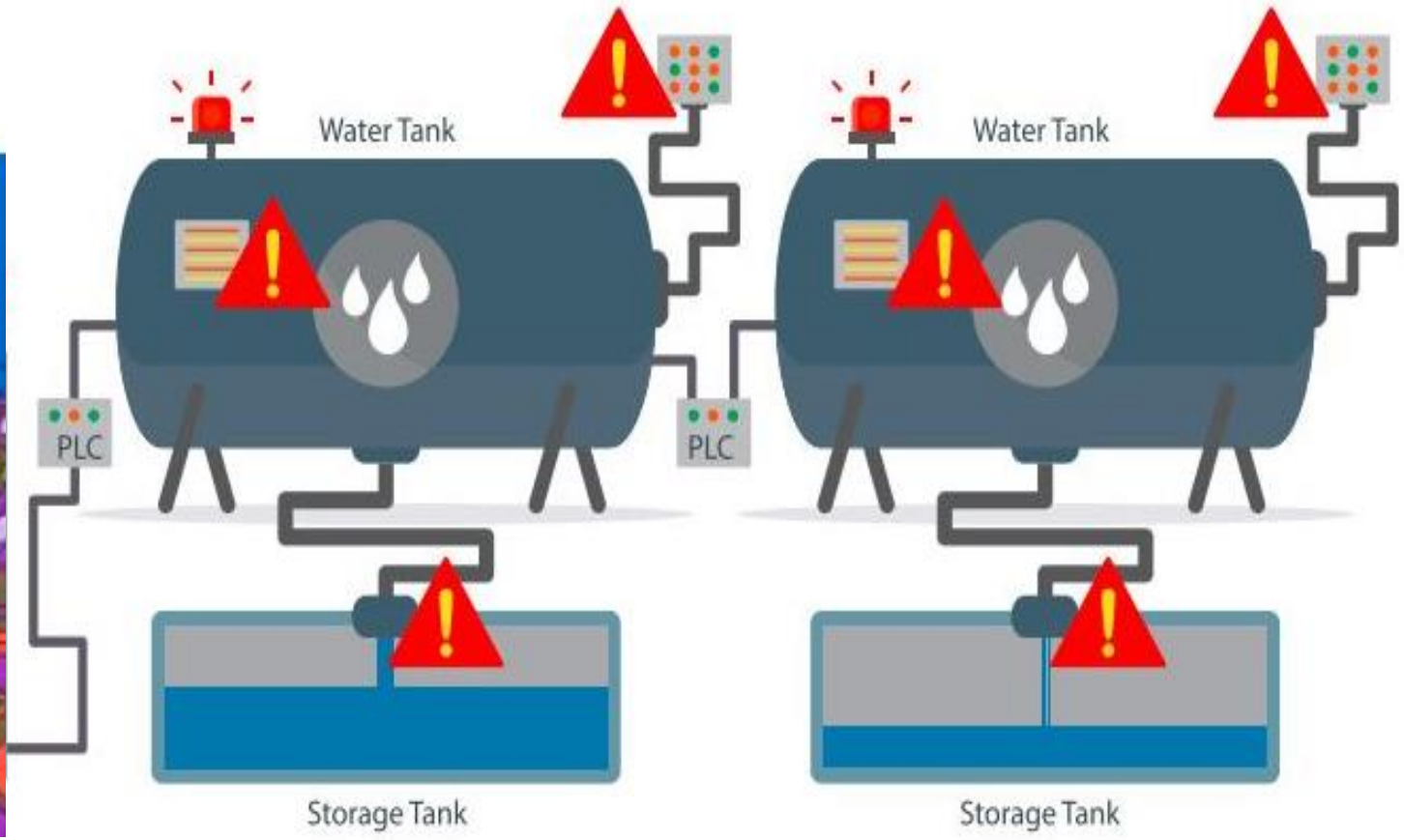
Breaks are overheating

Tire pressure is down

Motor temperature goes up etc.…



The Alarms Problem



Some History; Texaco Refinery, Milford Haven, 24 July 1994

The 1994 explosion and fire at the Texaco Milford Haven refinery in Wales, UK Injured 26 people and caused damage of around 48 million GBP and significant production loss. The Health and Safety Executive's (HSE's) investigation found out :

- There were too many alarm, and they were poorly prioritized.
- The HMI "Control Room Displays" did not assist the operators in identifying what was happening.
- There were neither adequate training nor clear guidelines for the operators to deal with a stressful plant upsets.

In the last 11 minutes before the explosion the two operators had to deal with 275 alarms. Almost an alarm each 2.4 seconds..

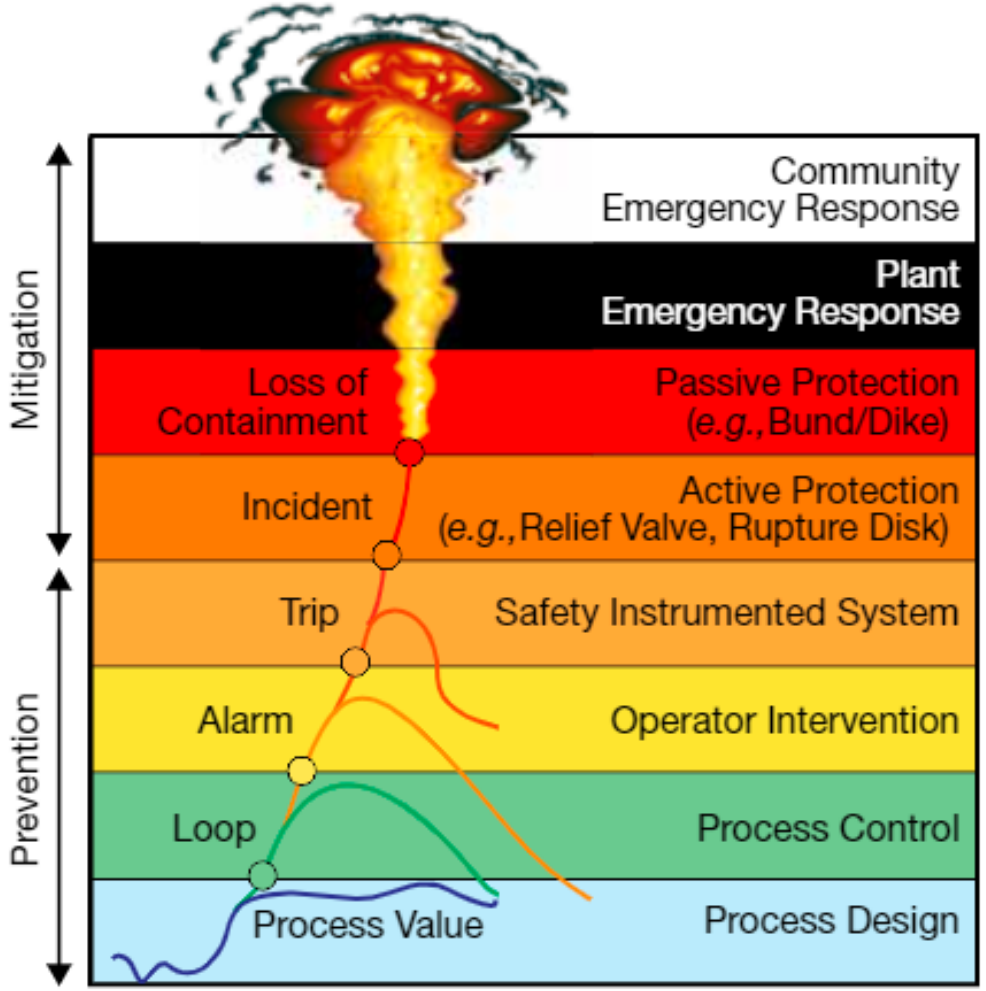
Some History; The Computer era

"The consequence - Massive over-configuration of alarms"

The More Alarms we have,
The better protected is our plant

Common Alarm Systems Issues

- Alarm Overload (Too many alarms for the operator)
- Alarm Floods
- Nuisance Alarms
  - Chattering Alarms
  - Standing Alarms
  - Repetitive Alarms (Bad Actors)
  - Redundant Alarms
- Alarms which have no response
- Alarms with wrong Priority
- Unclear HMI Messages, Displays and Navigation
- Operators Training



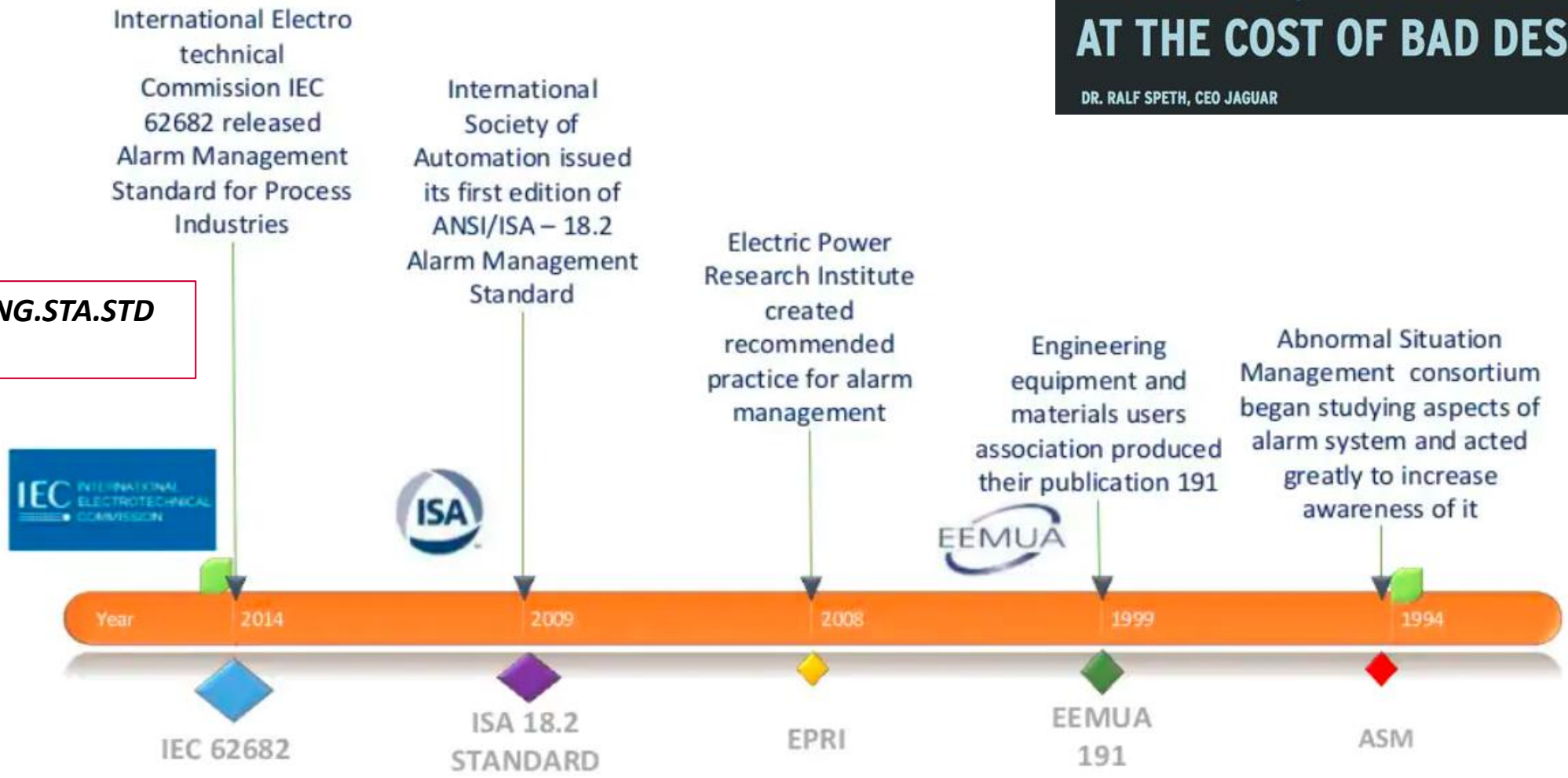
Alarm Management Standards

WE BELIEVE THIS APPLIES TO ALL DISCIPLINES:

"IF YOU THINK GOOD DESIGN IS EXPENSIVE, YOU SHOULD LOOK AT THE COST OF BAD DESIGN"

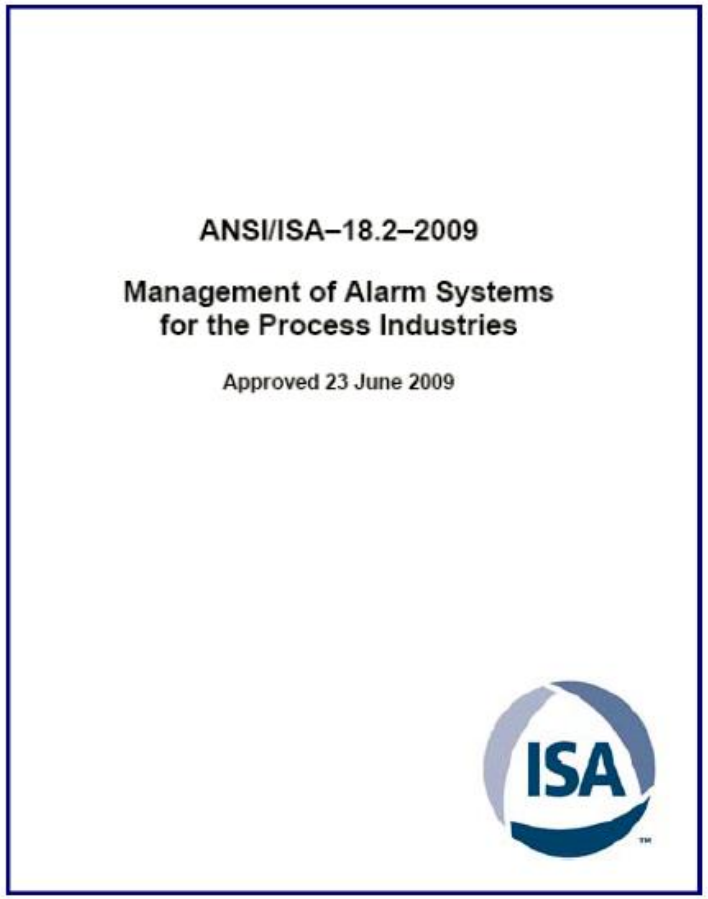
DR. RALF SPETH, CEO JAGUAR

eni: 28774.ENG.STA.STD (2017)

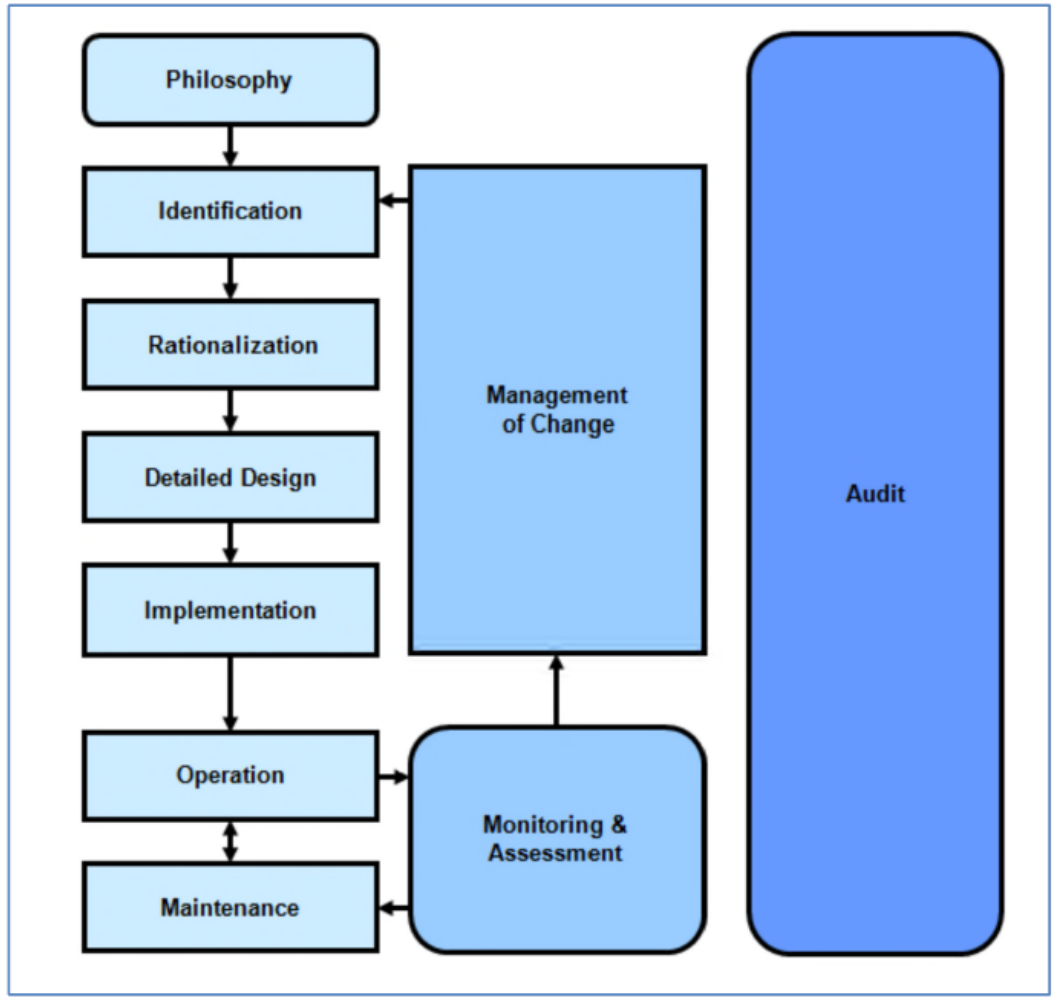


Alarm Management Lifecycle

ISA-18.2 Standard on Alarm Management



Requirements & Recommendations
(or IEC 62682)



Alarm Management Lifecycle

Alarm Management lifecycle 1/2 , from ISA 18.2

Alarm management lifecycle stage		Activities	Inputs	Outputs
Stage	Title			
A	Philosophy	Document the objectives, guidelines and work processes for alarm management, and ASRS.	Objectives and standards, audit recommendations	Alarm philosophy and ASRS.
B	Identification	Determine potential alarms.	PHA report, P&IDs, operating procedures, etc.	List of potential alarms.
C	Rationalization	Rationalization, classification, prioritization, and documentation.	Alarm philosophy, and list of potential alarms.	Master alarm database and alarm design requirements.
D	Detailed design	Basic alarm design, HMI design, and advanced alarming design.	Master alarm database and alarm design requirements.	Completed alarm design.
E	Implementation	Install alarms, implementation testing, and implementation training.	Completed alarm design and master alarm database, ASRS.	Operational alarms and alarm response procedures.

Alarm Management lifecycle 2/2 , from ISA 18.2

Alarm management lifecycle stage		Activities	Inputs	Outputs
Stage	Title			
F	Operation	Operator responds to alarms, and refresher training.	Operational alarms and alarm response procedures.	Alarm data.
G	Maintenance	Maintenance repair and replacement, and periodic testing.	Alarm monitoring reports and alarm philosophy.	Alarm data.
H	Monitoring & assessment	Monitoring alarm data and report performance.	Alarm data and alarm philosophy.	Alarm monitoring reports and proposed changes.
I	Management of change	Process to authorize additions, modifications, and deletions of alarms.	Alarm philosophy and proposed changes.	Authorized alarm changes.
J	Audit	Periodic audit of alarm management processes.	Standards, alarm philosophy, and audit protocol.	Recommendations for improvement.

Alarm Management Philosophy?

Alarm Philosophy Document

- What is an alarm?
- Roles and requirements.
- Rationalization requirements
- Alarm class definitions, design & requirements
- Alarm priorities, definitions, etc.
- Handling Techniques
- Alarm shelving
- Flood Suppression rules
- Alarm system monitoring requirements
- Management of change
- Training

Characteristics of a good alarm

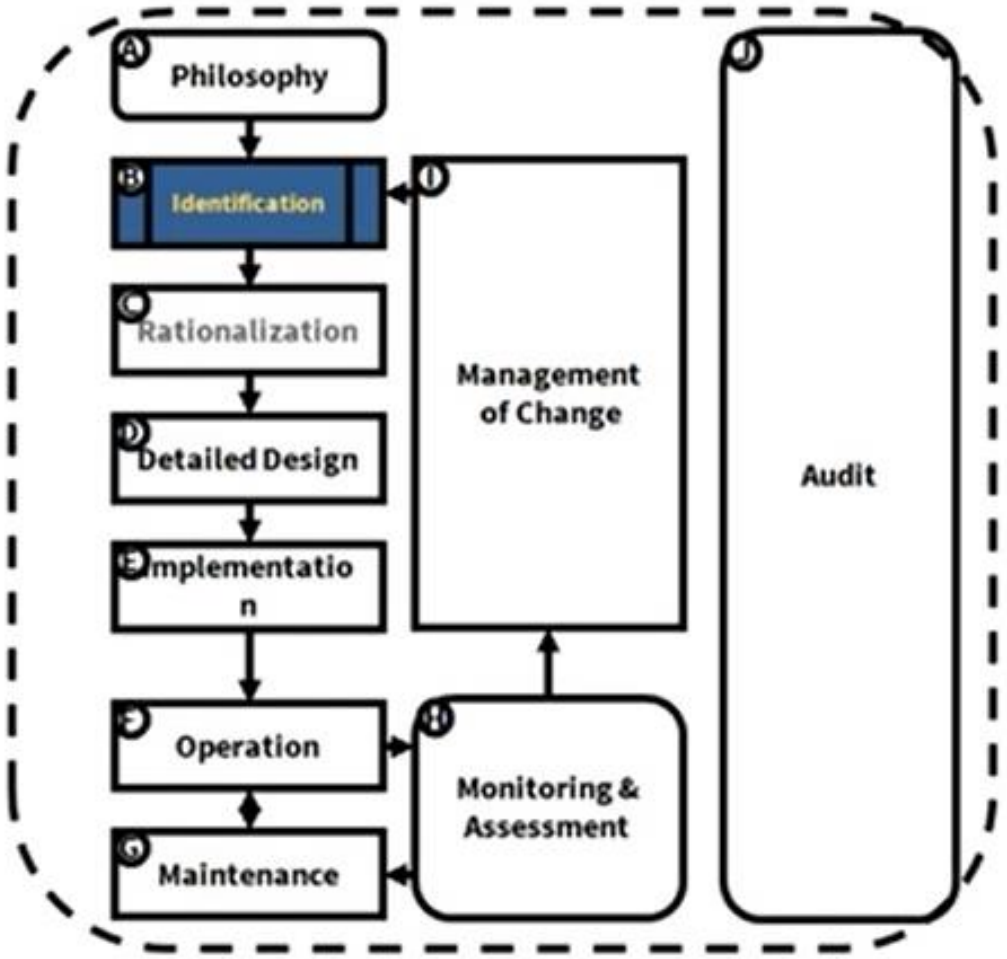
No Operator Response = No Alarm

Characteristics of a good alarm	
Relevant	i.e. not spurious or of low operational value
Unique	i.e. not duplicating another alarm
Timely	i.e. not long before any response is needed or too late to do anything
Prioritised	i.e. indicating the importance that the operator deals with the problem
Understandable	i.e. having a message which is clear and easy to understand
Diagnostic	i.e. identifying the problem that has occurred
Advisory	i.e. indicative of the action to be taken
Focusing	i.e. drawing attention to the most important issues

from EEMUA191

Alarm Identification

- ✓ P&ID reviews
- ✓ Operating procedures
- ✓ HAZOPs
- ✓ LOPAs
- ✓ Incident investigations
- ✓ Product Quality reviews
- ✓ Environmental Permits
- ✓ Existing Control System Configuration



Alarm Prioritization In-House

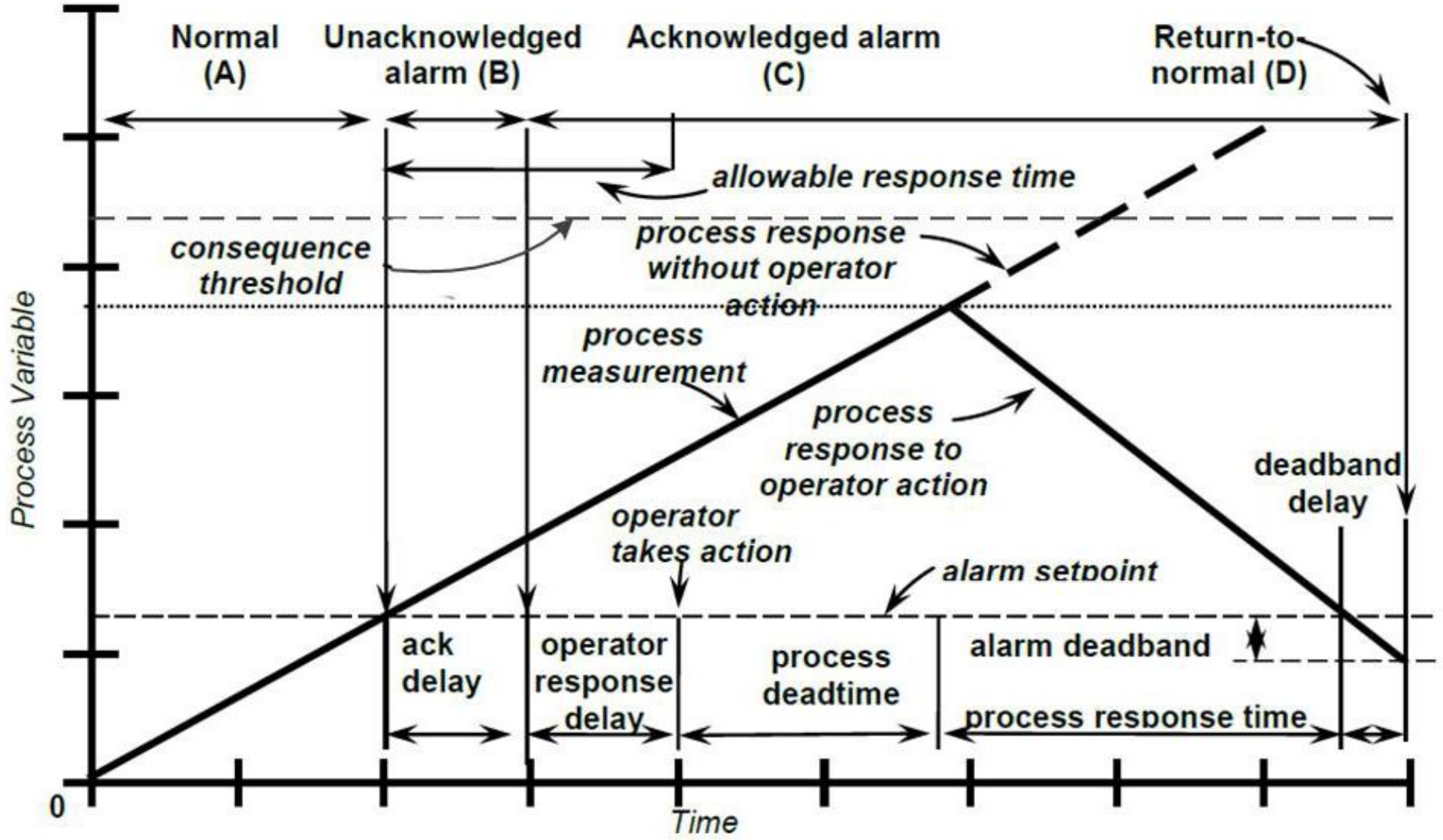
Business:	<$200,000	< $2,500,000	< $25,000,000
Community/Reputation:	Minor	Local Community Impact	Serious damage to reputation
Environment:	Minor	Localized	Major
Personnel/Safety:	Offsite Medical Treatment or 1 LTA	More than 1 LTA	Serious Disability or Death
Severity:	Minor	Moderate	Serious

No response = No Alarm

Urgency of Response	Minor Consequence	Moderate Consequence	Serious Consequence
> 30 minutes	Low	Low	Medium
3 to 30 minutes	Low	Medium	High
< 3 minutes	Medium	High	Critical

		AA30006	20" GAS LINE H2S INLET				
		Return to Normal	BQ	H(Analog)/Alarm(D)	L (Analog)	LL "not used"	HH "not used"
Is it an Alarm?			Yes	Yes	No	No	No
If it is an alarm? What is the response?			Trace the reading, check other AA30005 ...etc	Compare with AA30005 and check KTD20004	No Action	No action	Ensure Safe plant SD and check all F&G near open drain area
Urgency	Response Time	>30 min	3-30 min	<3 min	No action	No action	<3 min
Severity of not taking an action	Personal Safety		Minor	Moderate			Moderate
	Environment		Minor	Minor			Severe
	Business		Moderate	Moderate			Moderate
	Reputation		Minor	Minor			Moderate
Assigned Priority			Medium	High	Event	Event	Critical

Alarm Set Point vs Operator Response Time



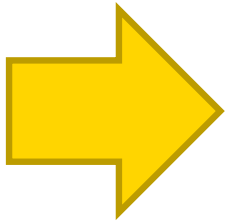
Detailed Design

- *Basic alarm design, which includes alarm types, deadbands, delays.*
- *HMI design, which includes indications, screens, colour coding, navigation and summaries.*
- *Advanced alarm design, which includes designed suppression.*
- *Alarm Tones (Audible Annunciation).*
- *Many nuisance alarms and stale alarms can be eliminated with good basic configuration practices.*

Implementation & Operation

Implementation

- Stage where the design is put
- into service
- Training for the operator
- included
- Initial testing of the alarm system functions



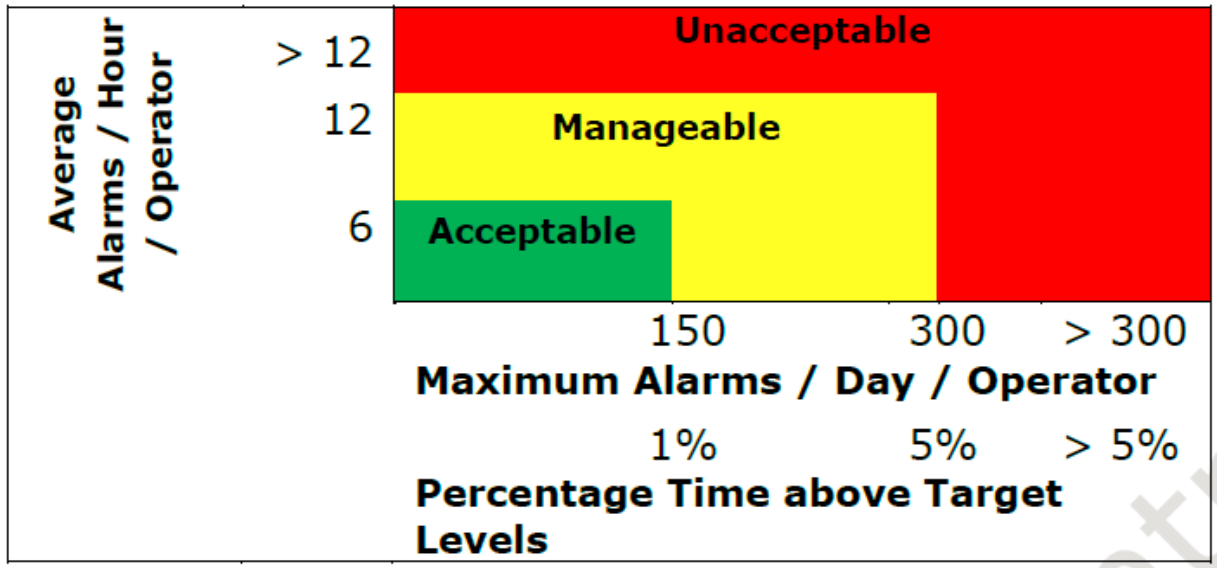
Operation

- Real Time Operations.
- Alarm System is in service
- Reporting abnormal conditions to the operator

Alarm System Maintenance

- Operators are monitoring performance and reporting any defects.
- Any necessary set points changes are investigated as per well defined MOC procedures.
- Process measurement instrument may need maintenance.
- Other components may need repair.
- Maintenance Strategy defines the inspection and repair methods.
- Periodic testing is a maintenance function.

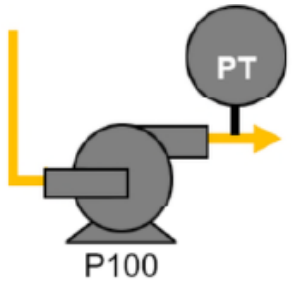
Monitoring and Assessment



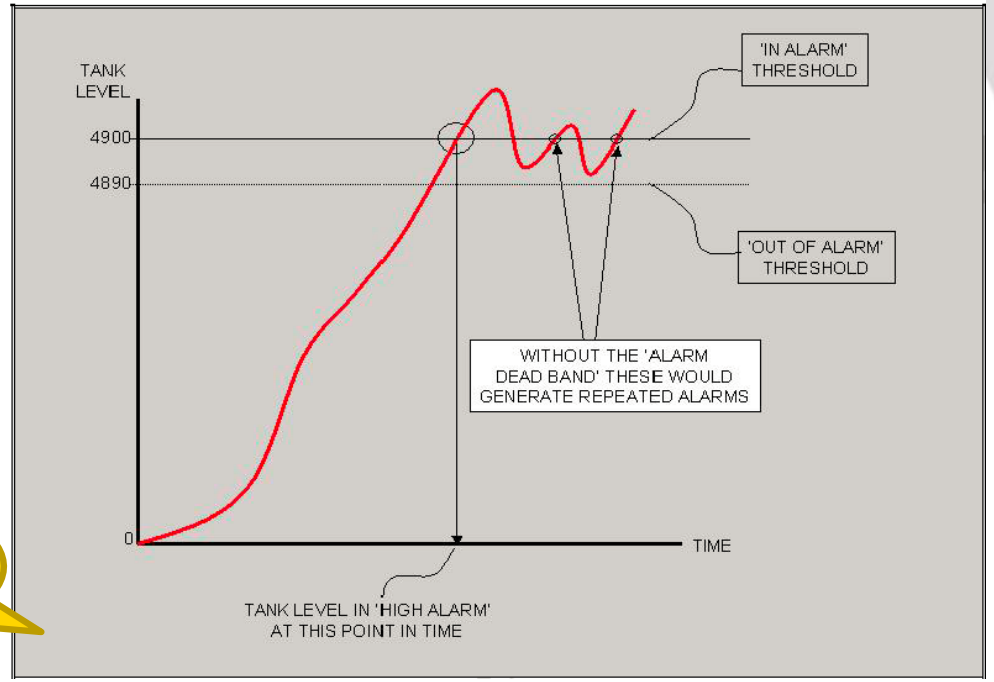
	EEMUA 191	ANSI/ISA-18.2	ASM
Average alarms per day	<144 (up to 288 may be manageable)	~150 (~300 may be manageable)	<144 (up to 288 may be manageable)
Average standing alarms	<10	<5 per day	<10
Peak alarms per 10 minutes	<10	≤10	<10
Average alarms per 10-minute interval	1	~1 (~2 may be manageable)	1
Distribution % (low/med/high)	80/15/5	80/15/5	80/15/5

Some Alarming Techniques

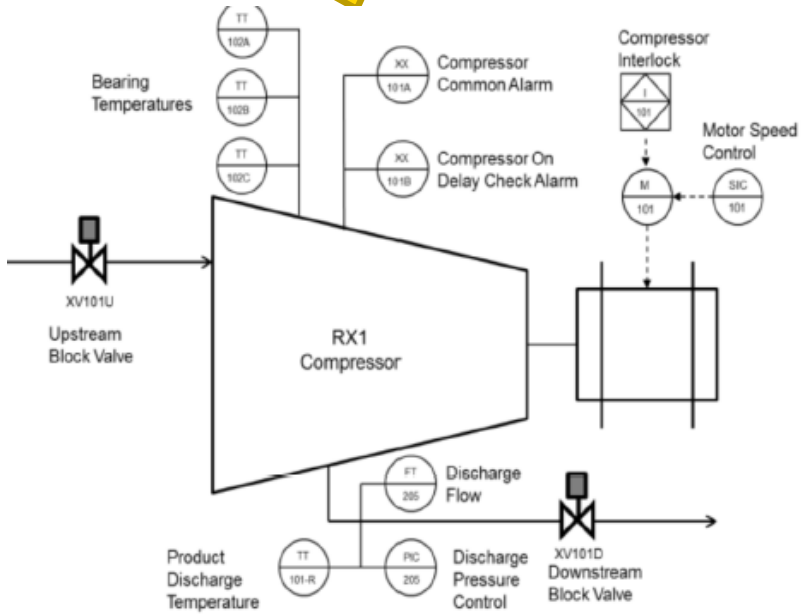
Conditional Alarming



Deadband



Dynamic Flood Alarming Suppression

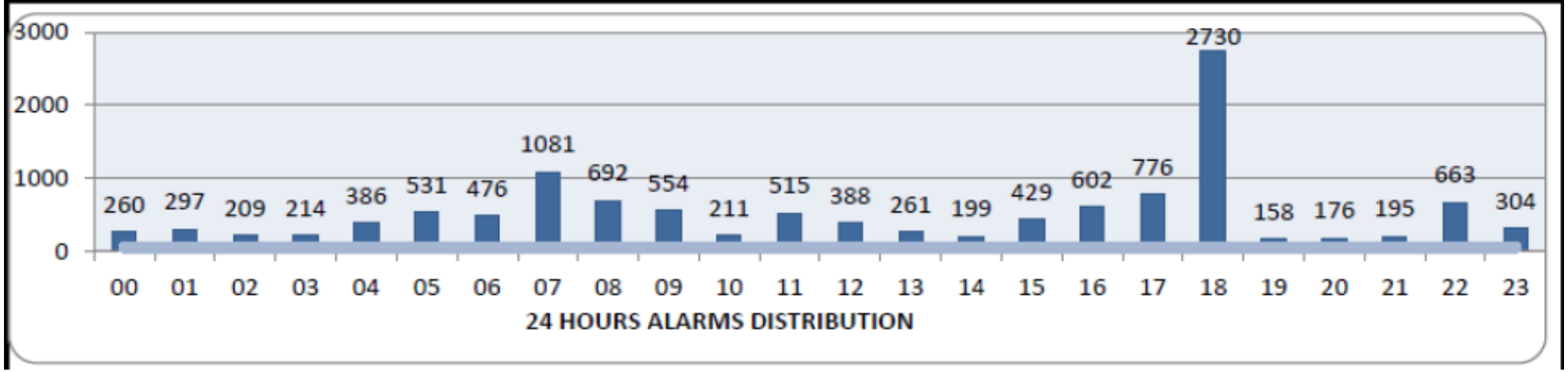


Tag	Description	Alarm
PT200	Fuel Supply Pressure	Low Alarm
XD201	Loss of Combustion Air	Discrete Alarm
XD202	Loss-of-Flame	Discrete Alarm
XD203	Loss of Actuating Energy	Discrete Alarm

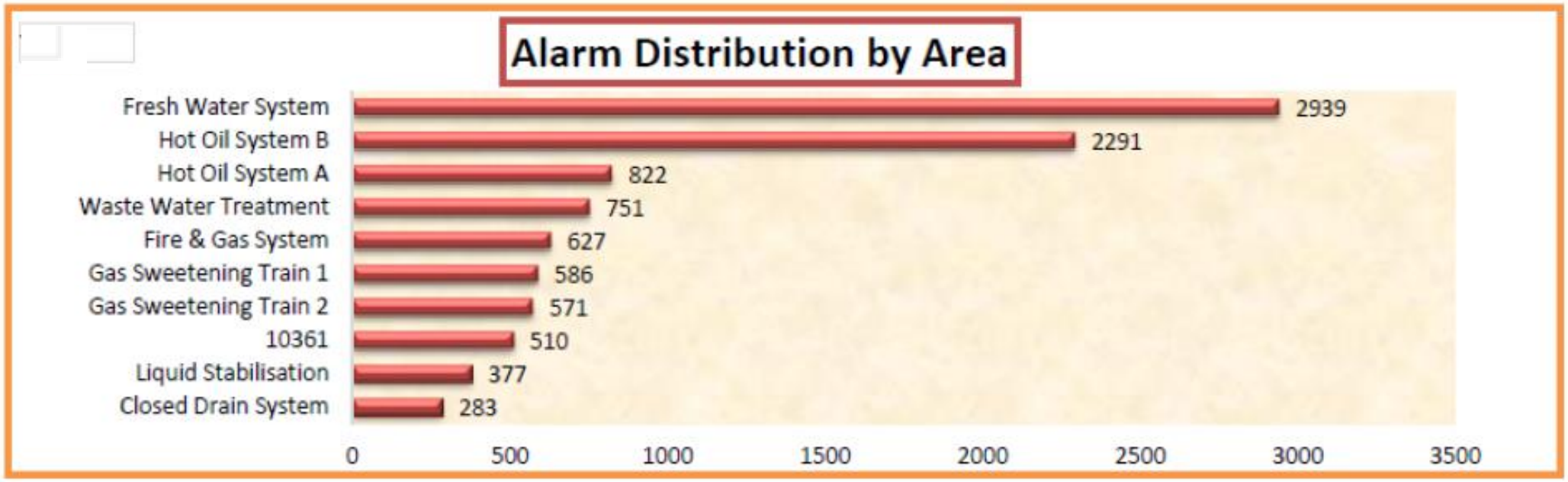
First Out-Alarming

Eni Experience – *Field 1*

Total Alarms	11737	Peak 10min (02/06/18 18:10): 993 Alarms		
Tag	**Alarms**	**%**	**Description**	**Area**	**Last occurrence**
10530LAL022	2567	22%	10530TM001 LEVEL ALARM LOW	Fresh Water System	2/6/2018 18:36
1B410FALL801	2284	19%	10410HW001B HO FLOW ALARM LOW LOW	Hot Oil System B	2/6/2018 23:37
1A410FAL802A	740	6%	10410HW001A COMB AIR FLOW ALARM L	Hot Oil System A	2/6/2018 23:20
10700XL015LS	486	4%	LINE FAULT FOR 10700XL015 (SS02)	Fire & Gas System	2/6/2018 17:38
10560PIC033	420	4%	10560XX004B (VA002B)	Waste Water Treatment	2/6/2018 23:58
10550LAHH001	222	2%	10550VA001 LEVEL ALARM HIGH HIGH	Closed Drain System	2/6/2018 23:28
10560PIC032	159	1%	10560XX004B (VA001B)	Waste Water Treatment	2/6/2018 17:19

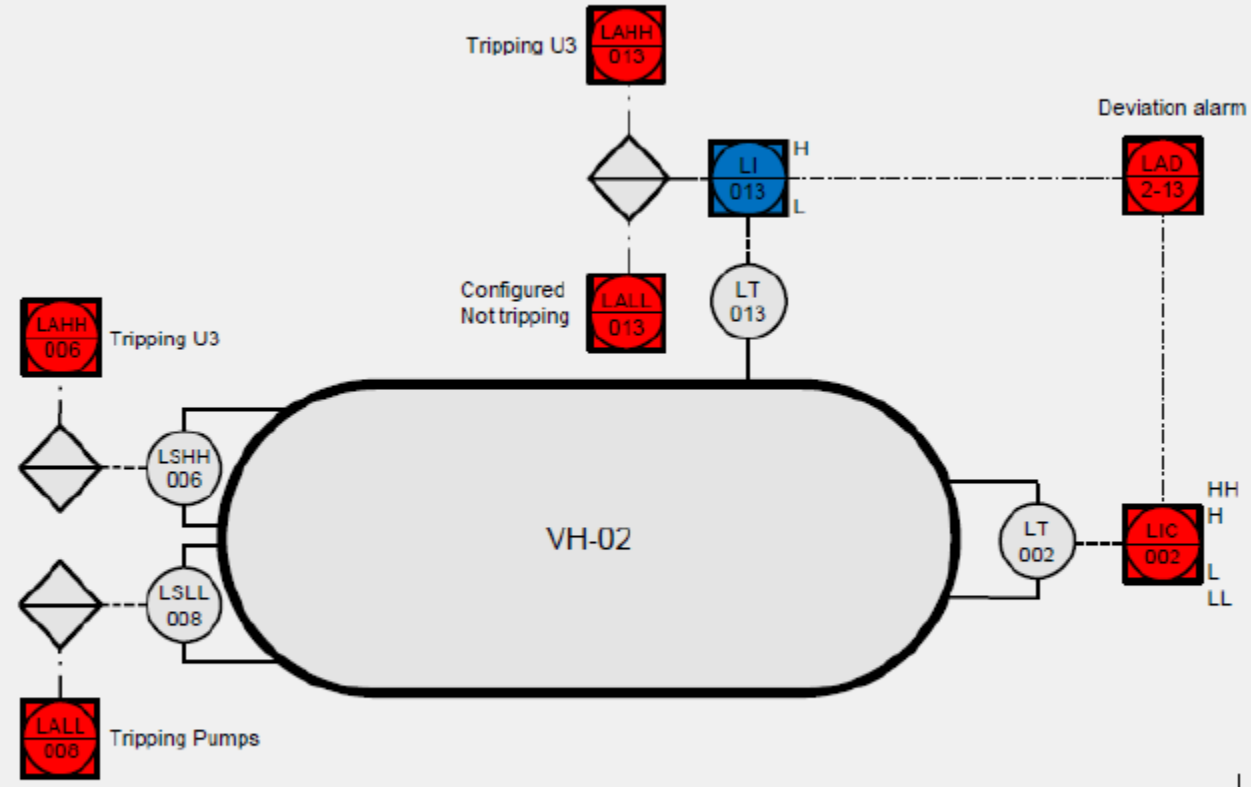


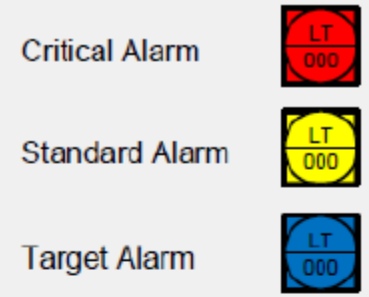
Eni Experience – *Field 1*



Eni Experience – *Field 2*

Degassing Level – Original Alarm Identification





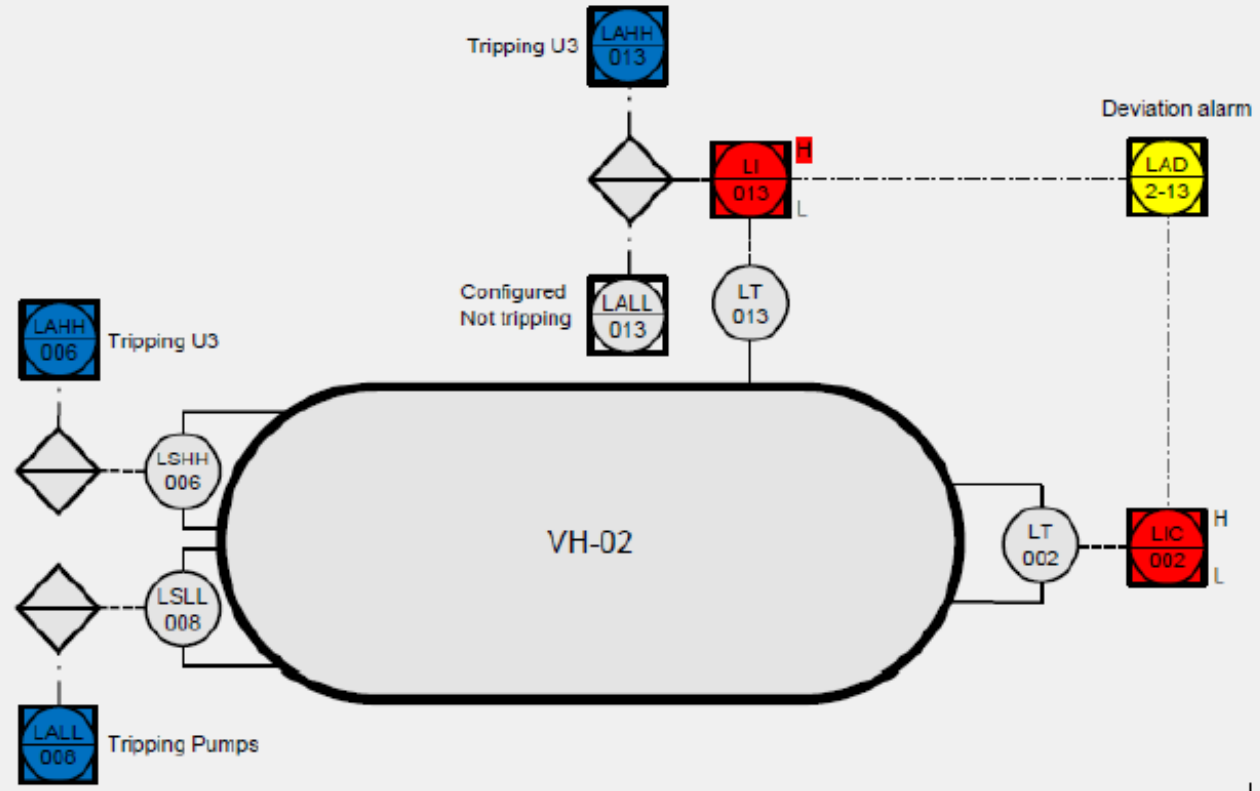
- Critical Alarm for ESD signal
- (Standard Alarm for F&G)
- Target Alarm for process

Unclear identification of the priorities

Validation	pre-trip	trip	FLOWLINE SD	TRAIN SD	GAS SD	CONDENSATE PUMP SD
		LSHH-006	X	X	X	X
	LAH-002 LAH-013	LAHH-013	X	X	X	X
LAD-2-13	LAL-002	LSLL-008				X

Eni Experience – *Field 2*

Degassing Level – New Alarm Identification



Critical Alarm LT 000

Standard Alarm LT 000

Target Alarm LT 000

Validation	pre-trip	trip	FLOWLINE SD	TRAIN SD	GAS SD	CONDENSATE PUMP SD
		LSHH-006	X	X	X	X
	LAH-002 LAH013	LAHH-013	X	X	X	X
LAD-2-13	LAL-002	LSLL-006				X

- Critical alarm for pre-trip alarm identyfing the cause
- Standard alarm for measure degradation,
- Target alarm for trip function

→ Enhanced identification of the hazard

Eni Experience – *Field 2*

Before AM

Alarm rate > 70 alarms/(console*hour)

Note: 1 alarm every 15 seconds, weekly avg.

Standing alarms > 2000 tags

Type of reportable events directly caused:

- SECE activation
- Production deferment
- HC Flaring
- Loss of fresh chemical

Total deferment cost above 1 million barrel during first year

OPEX increase ≈ 5%

Effect on plant reliability (< 80%)

KPI Definition

Priority 1 Alarm rate

< 1 alarm/(console*hour)

All console alarm

< 8 alarms/(console*hour)

Maintenance alarms

0 from F&G system

Standing Alarms

< 20 overall (long term)

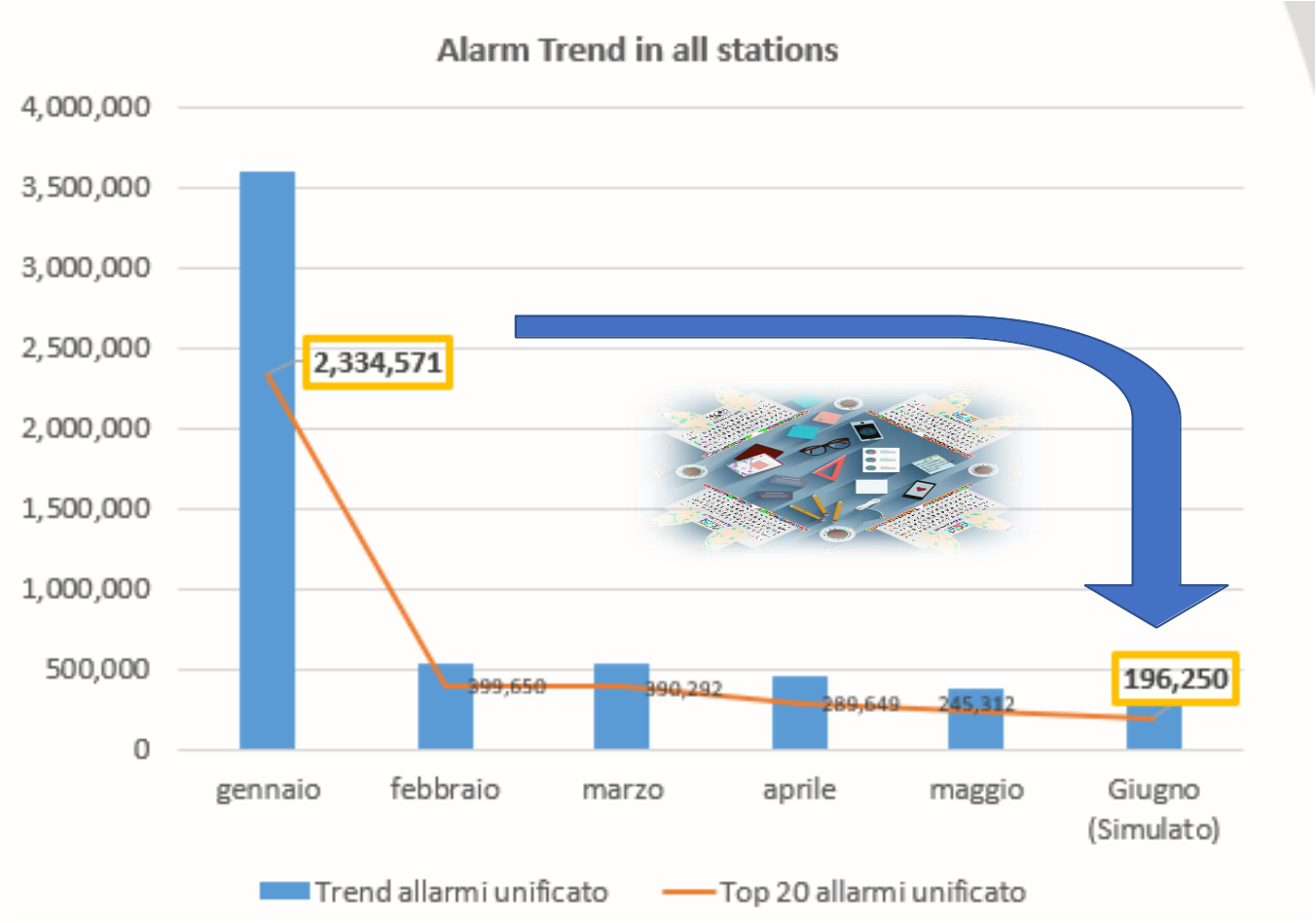
After AM

Alarm rate < 3 alarm/(console*hour)

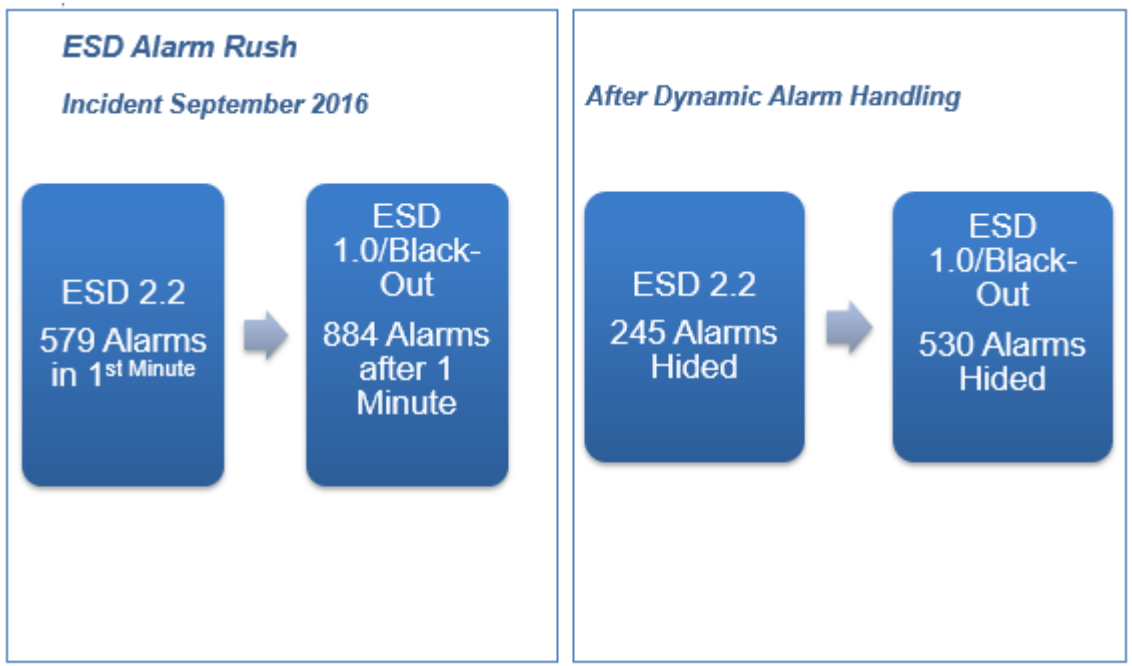
Standing alarm reduction by 75% (interim achievement)

Plant reliability exceeded 96% on yearly base with monthly peak of 99.9%.

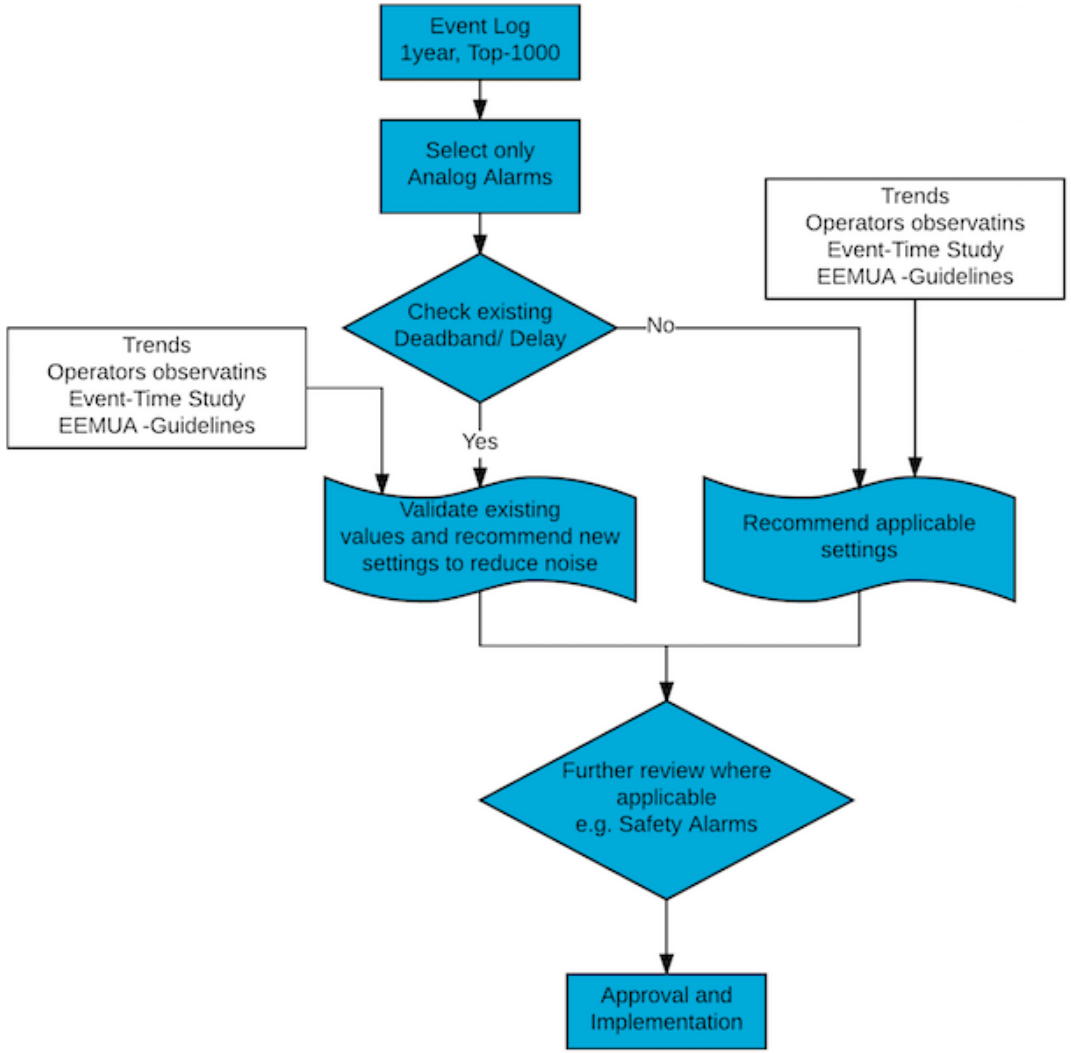
Eni Experience – *Field 3*



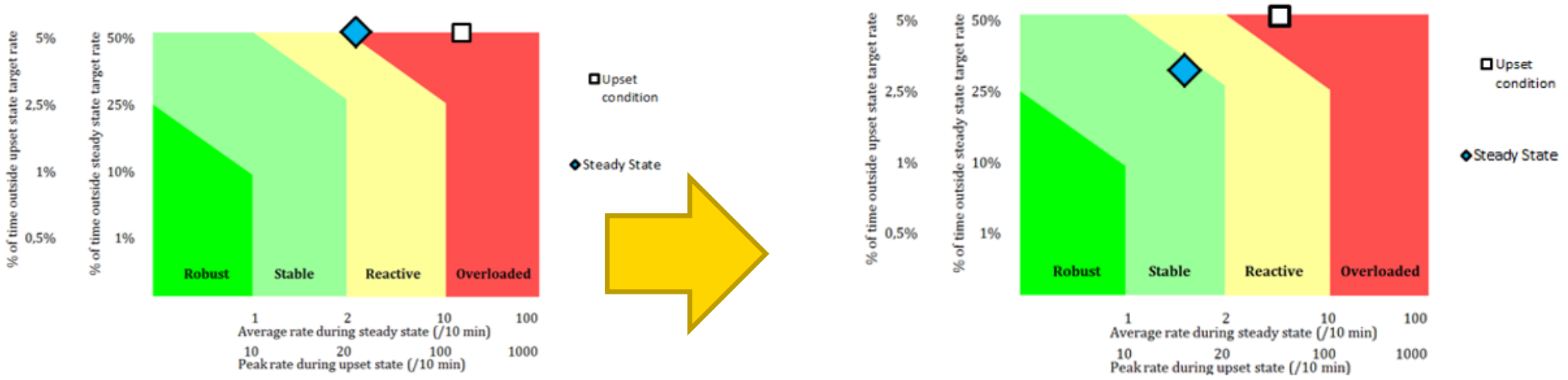
Eni Experience – *Field 4*

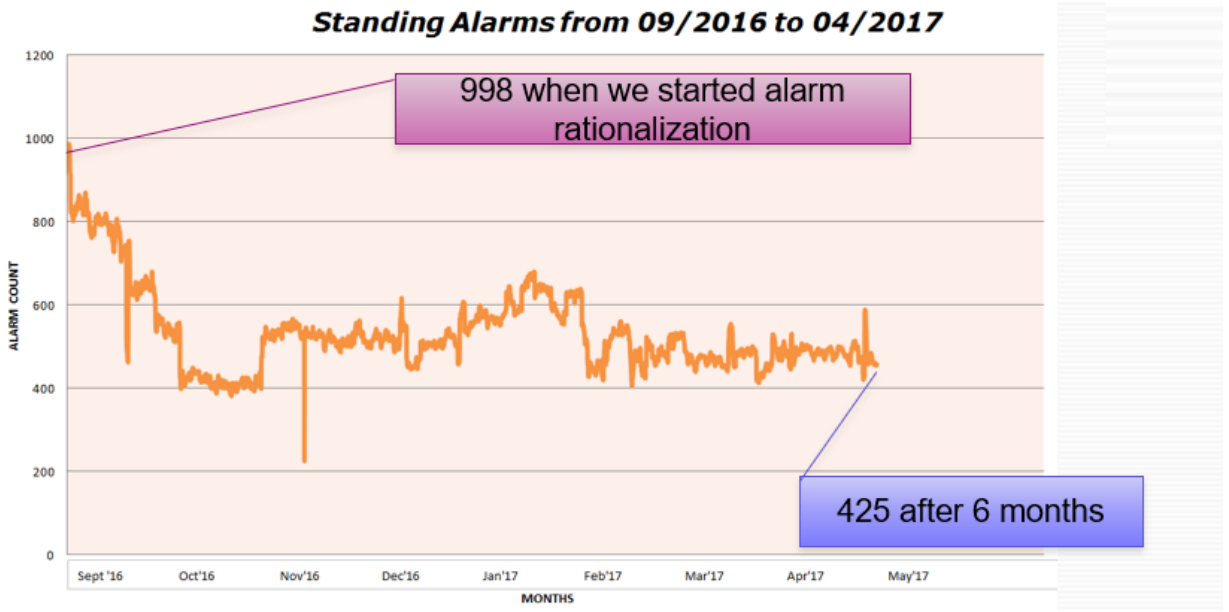


Reduction of 48% alarms during ESD alarm rush!



Eni Experience – *Field 4*





Eni Experience – *Field 5*

Alarm Rate By Console for 1/1/2020 to 2/1/2020		Likely to be Acceptable	Maximum Manageable
Annunciated Alarms Per Day Per Operating Position	134	<150	300
Annunciated Alarms Per Hour Per Operating Position	5.57	<6	12
CRITICAL Priority Alarms Per Hour Per Operating Position	1.16	N/A	N/A
WARNING Priority Alarms Per Hour Per Operating Position	4.35	N/A	N/A
ADVISORY Priority Alarms Per Hour Per Operating Position	0.05	N/A	N/A
Percentage of Hours With > 30 Alarms Per Operating Position	3.70%	<1%	1%
Stale Alarms (>24 hrs)		<5	5
Suppressed Alarms		0	0
Shelved Alarms		0	0

Percent of Days with Daily Count Per Operating Position			Target is:
Less than 20	0.00%	Exceptional	
20 to 49	16.13%	Very Good	100% Total
50 to 150	54.84%	Acceptable	
150 to 300	19.35%	Managable	0% Total
More than 300	9.68%	Unmanagable	

		Target	
Annunciated Alarms Per 10 Minutes Per Operating Position	0.93	<1	2
Percentage of 10 Minute Periods with more than 10 Alarms	0.69%	<1%	
Maximum Number of Alarms in a 10 Minute Period	84.5	<= 10	
Percentage of Time Alarm System is in Flood	1.19%	<1%	

Benefits of Alarm Management implementation

Reduction
of noise in control room

Rationalization
of operator attention

Improvement
in time utilization

Improvement
of response time

Maximization
of plant efficiency

Improvement
in plant reliability

Reduction
of OPEX

Reduction
of insurance premiums

Alarm Management: External Resources

- *"Alarm Systems: A Guide to Design, Management and Procurement", EEMUA Publication No. 191, Third Edition.*
- *ANSI/ISA-18.2: "Management of Alarm Systems for the Process Industries".*
- *"IEC 62682 "Management of alarms systems for the process industries" 2014*
- *The UK HSE guidance note "Better Alarm Handling".*
- *ANSI/ISA-S84.01 "Application of Safety Instrumented Systems for the Process Industries".*
- *"Principles for alarm system design", Norwegian Petroleum Directorate*

Thanks for your kind attention

BACKUP

Typical Robust Alarm System - EEMUA191

	State 1 - Robust
Characteristics	• Alarm system is reliable during all plant modes including normal operation and plant upset. • Operators have a high degree of confidence in the alarm system and have time to read and understand all alarms.
Typical operator interface	• The alarm response manual, containing the expected operator action in response to each alarm and the likely consequence of this being ineffective, is available on-line (i.e. integrated into the DCS alarm system interface) for the operator to consult as necessary. • The alarm system adjusts automatically according to plant operating mode, displaying only the alarms that are relevant under the current conditions. • Priority safety and priority production alarms are always displayed in the same location on the operator interface to facilitate pattern recognition.
Typical alarm system functionality	• DCS alarm system is fully enhanced for optimal alarm management. • A large proportion of the alarms are treated dynamically, so that they can be annunciated to the operator only when they have a response that is appropriate for the current operating mode. • Manually-initiated bulk suppression of alarms is possible, based on a range of criteria (including priority- and equipment-based), and this is consistently used by the operators. • Adaptive alarm tuning is applied consistently, e.g. to automatically suppress bouncing alarms. • Some use is made of model-based alarming, to warn of deviation from multivariate relationships, before single measurements become significantly upset.
Typical ancillary processes	• A full process of continuous improvement is established and running for the alarm system with identified responsibilities and accountabilities. Key performance indicators are published at a high level in the organisation.

Operator Questionnaire 1/2 – EEMUA 191

Location:	'Plant location'
Plant:	'Plant name'
Date:	
Name:	
Role:	

1. How long have you worked with the present control/alarm systems? (E)

	Years		Months

Have you worked with other systems? If so, which ones?

What features of the other systems do you like?

2. About your control/alarm systems

Control System details (Name/ Manufacturer/ Model/ MMI/ Year installed)

Is the alarm system part of the control system?	
Are there fixed annunciator panels?	

What other systems generate alarms you respond to?

3. How well do the alarm systems support you in normal steady operations? (E)

Very good	OK	Poor	Very poor

What series of operations do you do when an alarm is activated?

4. How well do the alarm systems support you during plant fault or trips? (E)

Very good	OK	Poor	Very poor

What is your impression of the number of alarms generated when equipment trips or communications fails?

Is there more than one operator who accepts/responds to the alarms? If so, how many?

Are alarms grouped say by plant area, equipment for each operator?

5. What about the total number of alarms in the system? (E)

Too many alarms	Many but necessary	Few but adequate	Too few alarms

Can you distinguish between alarms generated from different parts of the system?	Yes/Not at all/In part

What generates most alarms? (1- being the highest)

Process	Equipment	DCS system	Communications	Instrument faults

6. How many alarms do you get in normal steady operation? (E)

PER HOUR

Guess		Per hour
Actual		Per hour

7. How often do you find that an alarm that comes up is a repeat of an alarm you have already seen in the last five minutes? (E)

70-100% of alarms	40-70% of alarms	20-40% of alarms	Under 20% of alarms

8. Do you suffer from the following 'nuisance' alarms?

	Often	Sometimes	Rarely
Alarms that are wrongly prioritised.(E)			
Alarms from plant that is shut down.(E)			
Two or more alarms occurring at the same time that mean the same.(E)			
Alarms occurring in a trip which are only relevant in steady operation (E)			

9. What proportion of alarms are useful to you in operating the plant? (E)

All essential	Most useful	Few useful	Very few useful

10. Do you fully understand each alarm message and know what action to take? (E)

Always	Mostly	Sometimes

Operator Questionnaire 2/2 – EEMUA 191

9. What proportion of alarms are useful to you in operating the plant? (E)			
All essential	Most useful	Few useful	Very few useful

10. Do you fully understand each alarm message and know what action to take? (E)		
Always	Mostly	Sometimes

11. Consider a normal operating situation and 10 typical alarms. How many of the 10 alarms:-	
Require you to take positive action, e.g. operate a valve, or speak to an assistant?(E)	
Cause you to bring up a display/format and monitor something closely?(E)	
Are noted as useful information?(E)	
Are read and quickly forgotten?(E)	

12. How many alarms would you get during a large plant fault or trip? (E)		
In the first minute	In the next ten minutes	In the next hour
What facilities help you manage alarms during a large plant upset?		
What facilities would help you if there were a large amount of alarms during a plant upset?		

13. Do you keep an alarm list permanently displayed during a large plant fault or trip? (E)			
Yes		No	

14. How often do you look through the alarm list display during a large plant fault or trip? (E)			
Several times a minute	Once every couple of minutes	Once every 10 minutes	Less than once every 10 minutes

15. How often in a large plant fault or trip do the alarms come too fast for you to take them in? (E)		
Mostly	Sometimes	Rarely

16. How often in a large plant fault or trip are you forced to accept alarms without having time to read and understand them? (E)			
Always	Quite often	Sometimes	Never

17. Does the alarm system help you to pick out key safety related events during a large plant fault or trip?			
Very well	Some help	Little help	A nuisance

Nuisance Alarm Flowchart