Mutual Joint Visit Workshop for Seveso Inspections on Risk management and enforcement for ageing sites

Malta 10th april 2019

Method for the synthetic evaluation of the adequacy of the asset integrity management in Seveso plants

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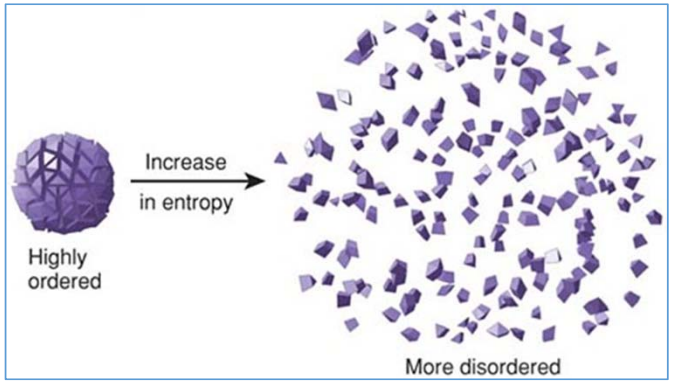
Aging General Concept

Corrosion, erosion, fatigue, creep are irreversible phoenomena ….



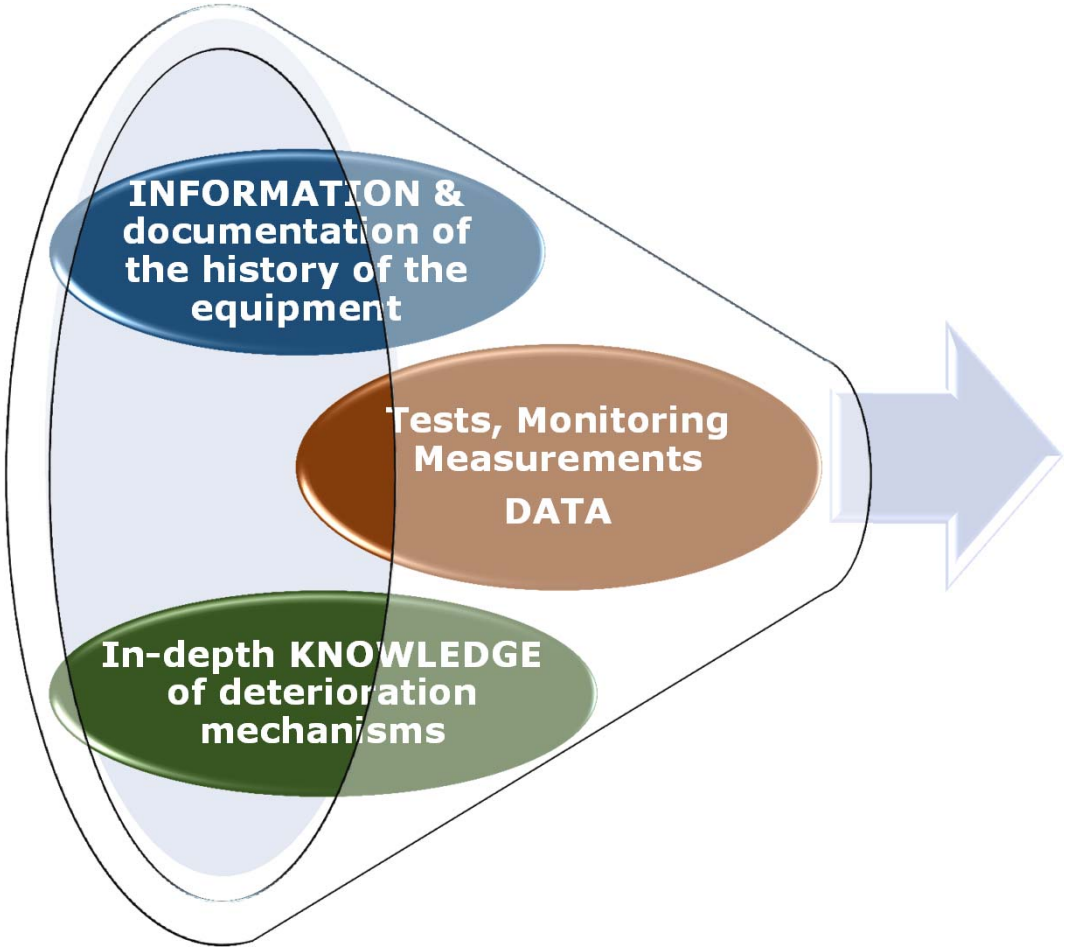
Ludwig Boltzmann (1875) $S = K \log W$
(entropy – probability - disorder)

Claude Shannon (1948)
(entropy – probability - information)

Risk = f(probability, conseguences, uncertainty)

In closed systems, entropy / uncertainty inevitably increases. In open systems, work must be provided to increase information and decrease the variation in entropy / uncertainty.

→ Reduce uncertainties



Knowledge

Information

Data

DIRECTIVE 2012/18 / UE of the European Parliament and Council of 4 July 2012 on the control of the danger of major accidents involving dangerous substances ...

ANNEX III, art. 10 (management system)
..... monitoring and control of the risks associated with aging of the equipment installed in the plant and corrosion; ...

Legislative Decree June 26, 2015, n. 105 Implementation of Directive 2012/18 / EU on the control of major-accident hazards involving dangerous substances ...

ANNEX 3 art. 14 (management system)
... .. monitoring and control of the risks related to the aging of the equipment installed in the plant and to corrosion; ...

ANNEX H, art. 27 (inspections)
Verify that a monitoring and integrity check plan has been envisaged to prevent potential risks associated with aging (corrosion, erosion, fatigue, of equipment and systems that can lead to the loss of containment of dangerous substances;

Purpose:

To allow auditors a quick evaluation of ageing management programs, within the strict time limits of the inspections.

Field of application:

Primary containment equipment
Out of scope: Valves, rotating organs, instrumentation

Definitions:

Critical equipment for the purposes of the relevant accident:
Equipment that is included in the fault tree leading to a top event.
Equipment containing dangerous substances in quantities higher than 5% of the Seveso higher threshold.

Not considered equipment obsolescence, ageing of organizations and staff and other related topics are not included.

INAIL DIT coordinator Paolo Bragatto

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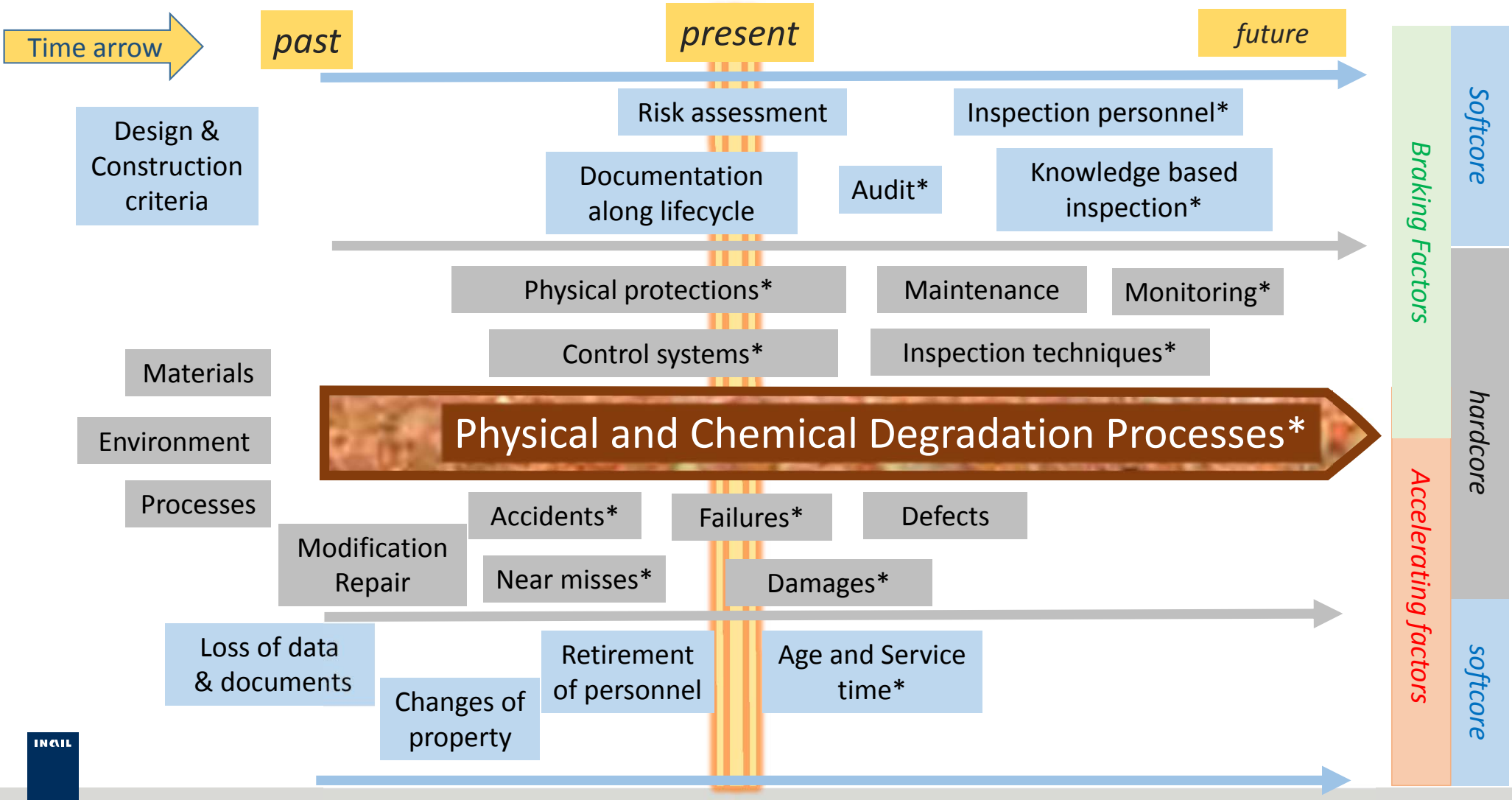
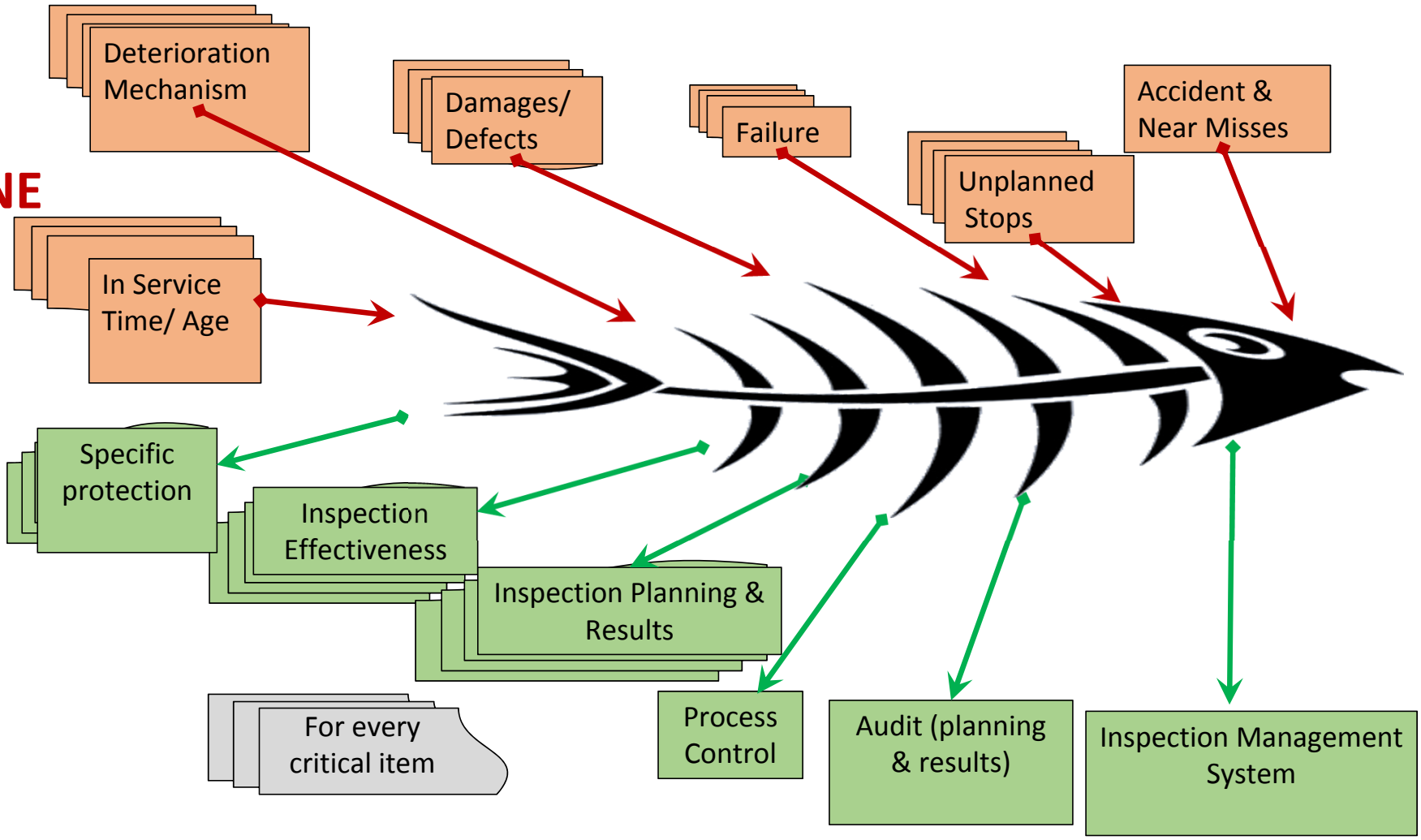

Time arrow
past
present
future
Design & Construction criteria
Risk assessment
Inspection personnel*
Documentation along lifecycle
Audit*
Knowledge based inspection*
Physical protections*
Maintenance
Monitoring*
Control systems*
Inspection techniques*
Materials
Environment
Processes
Physical and Chemical Degradation Processes*
Accidents*
Failures*
Defects
Modification Repair
Near misses*
Damages*
Loss of data & documents
Changes of property
Retirement of personnel
Age and Service time*
Braking Factors
Softcore
hardcore
Accelerating factors
softcore

FISHBONE MODEL



PENALTIES & COMPENSATIONS

- Factors are qualitatively estimated.
- Accelerating factors give penalties, instead retardating ones give compensations.
- Four categories of scoring: 1 = low; 2 = medium; 3 = medium-high; 4 = high.
- Negative sign for penalties and positive for compensations.
- Average accelerating factors, an indicator of the proneness to ageing.
- Average control factors provide the indicator of control capability

If capability to control < proneness to ageing
CRITICAL

If capability to control > proneness to ageing
ADEQUATE

Characteristics of the method:

Proportionality.

If the negative score is low (accelerating factors), also the required activities are few (retarding factors), + accelerating factors => + retarding factors

Freedom

The manager is free to choose between the possible activities,unlike the check list the braking factors are complementary to each other

Simplicity

Algebraic sum of non-negative retardiing and accelerating factors
No more is required!

ACCELERATING FACTORS

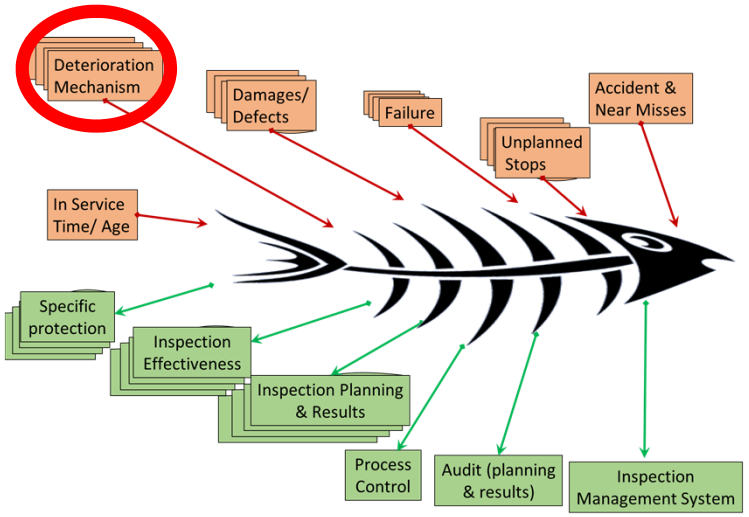
Factor	Score	Value
Accidents/ Near-misses	1 2 3 4	≤ 5 % 5 ÷ 15 % 15 ÷ 35 % > 35 %
Defects/ Damages	1 2 3 4	≤ 1 % 1 ÷ 3 % 3 ÷ 5 % > 5 %

For establishment

Factor	Score	Value
Age/In-service time	1 2 3 4	≤ 90 % 90 ÷ 100 % 100 ÷ 125 % > 125 %
No. of unplanned stops	1 2 3 4	≤ 10 % 10 ÷ 25 % 25 ÷ 60 % > 60 %
Failures	1 2 3 4	≤ 0.5 f_{ref} 0.5 f_{ref} ÷ 1.0 f_{ref} 1.0 f_{ref} ÷ 2.0 f_{ref} > 2.0 f_{ref}
Deterioration mechanisms	1 2 3 4	(i) consequences, (ii) ability to detect mechanisms, (iii) propagation velocity

For any critical item

Deterioration mechanisms:
It is linked to the severity of the consequences, to the ability to detect the main damage mechanisms (by inspection), to the velocity of damage propagation, to the level of variability of the phenomenon.



The value of the scores obtained from each critical elements must then be mediated on all the elements

For each critical element, identify the different deterioration mechanisms, assign a score to each mechanism and assign to the critical element the highest score (dominant mechanism)

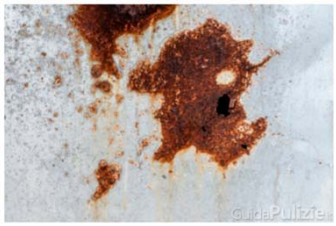
Meccanism 1
Erosion-corrosion

Meccanism 2
Corrosion fatigue cracking

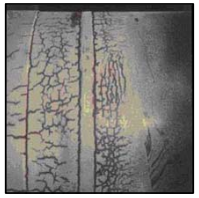
Meccanism 3
Corrosion under Insulation

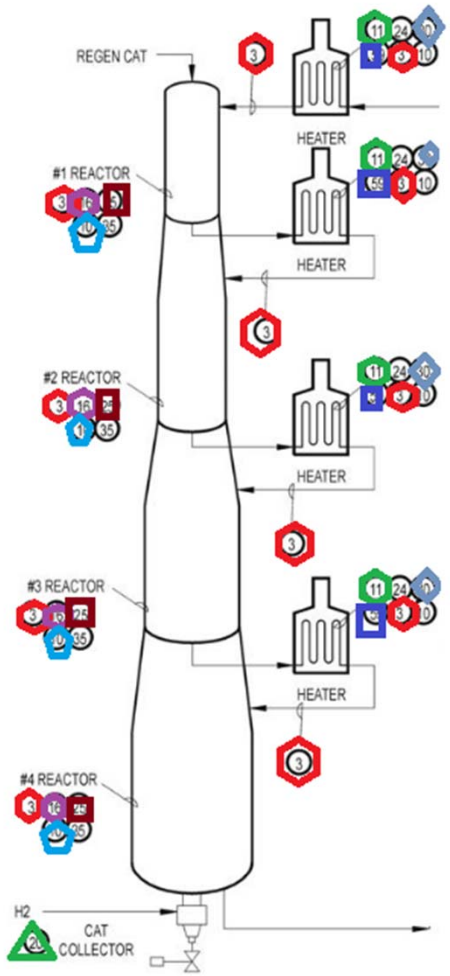
Meccanism 4
Atmospheric corrosion

Help!




Edge of
metal
loss




REGEN CAT
HEATER
#1 REACTOR
HEATER
#2 REACTOR
HEATER
#3 REACTOR
HEATER
#4 REACTOR
H2
CAT
COLLECTOR

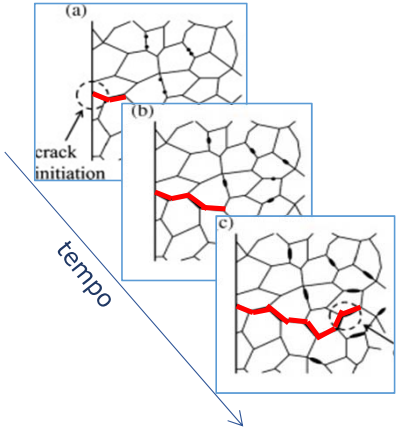

Creep / Stress Rupture
Ammonium Chloride Corrosion
HCl Corrosion
High Temperature Hydrogen Attack
Oxidation
Temper Embrittlement
Erosion / Erosion-Corrosion
Carburization
Hydrogen Embrittlement
Short Term Overheating - Stress Rupture
Reheat Cracking
Ammonia Stress Corrosion Cracking
Cooling Water Corrosion
Mechanical Fatigue
Metal Dusting

IDENTIFICATION OF MAIN DETERIORATION MECHANISMS

Detectability:

Easy detection of the phenomenon and measurement of the effects.

SCORE	Description
1	Easy (Visual examination)
2	Quite Easy (Non Distructive Control)
3	Quite Difficult (Probe)
4	Difficult (Invasive Test)



Velocity:

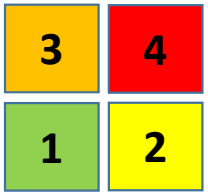
The propagation of the phenomenon is linked to time.

SCORE	Description
1	Time Scale >10 years
2	Time Scale 5 ÷ 10 years
3	Time Scale 2 ÷ 5 years
4	Time Scale < 2 years

Consequences:

Entity of the loss of containment provoked and its danger

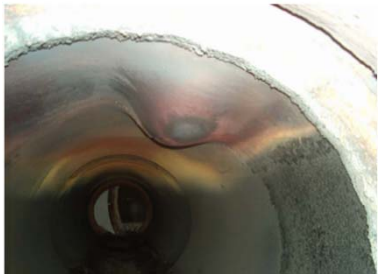
SCORE	Description
1	No Loss
2	Cracks
3	Holes
4	Structural Failure

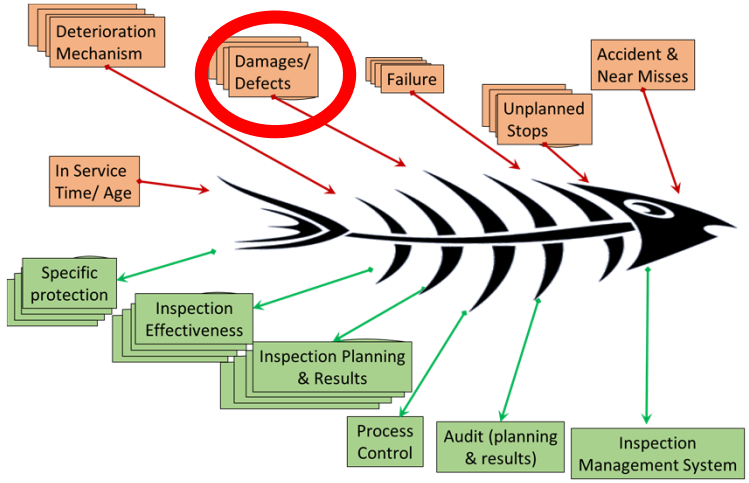


Type of mechanism	DETECTABILITY	VELOCITY	CONSEQUENCE	SCORE
LONG TERM Metallurgical	4	1	4	**3**
SHORT TERM Metallurgical	4	4	4	**4**
LOCAL THINNING	4	3	4	**3**
UNIFORM THINNING	2	2	3	**2**
ENVIRON Corrosion	1	1	2	**1**
SCC Stress Corrosion Cracking	4	2	4	**3**
HTHA High Temperature Hydrogen Attack	4	3	4	**4**
Fatigue	3	3	4	**3**
CREEP	3	3	3	**3**
CUI Corrosione under coibentation	4	3	4	**4**

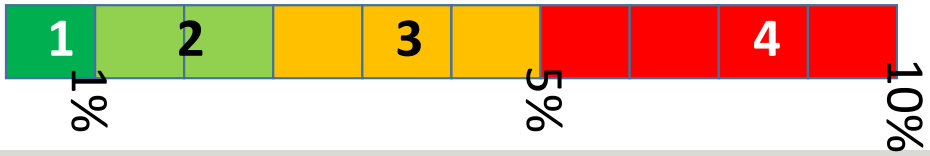
DAMAGE FACTOR

It relates to the incidence of serious damage and defects detected during the checks carried out on critical elements. Minor faults that do not compromise functionality are not considered.





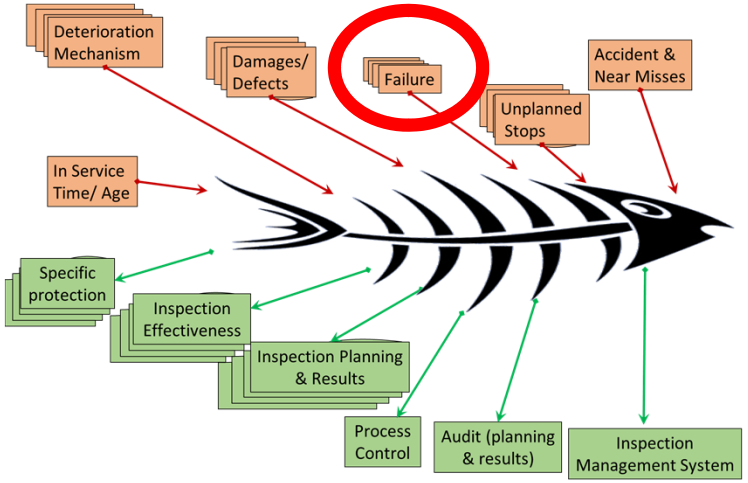
For each critical element identify the number of damages found during the control and verification activities of the last 10 years. Calculate the Ratio between total number of damages and number of critical elements.



FAILURE RATE

Get the real failure rate recorded on components for a period of 10 years.

The value obtained must be compared with the failure rate reported in the reference database (HSE/FRED, OREDA) used for the preparation of the Safety Report.



Score	Ratio
1	< 0,5
2	0,5÷1
3	1,0÷2,0
4	>2,0

RETARDING FACTORS

Factor	Score	Value
Inspections effectiveness	1 2 3 4	Average score: (i) effectiveness of inspections (ii) inspector qualification
Specific protections	1 2 3 4	Average score: (i) inspection intervals, (ii) protection's conditions
Inspection results	1 2 3 4	Average score: (i) test results, (ii) inspections planning (scheduling)

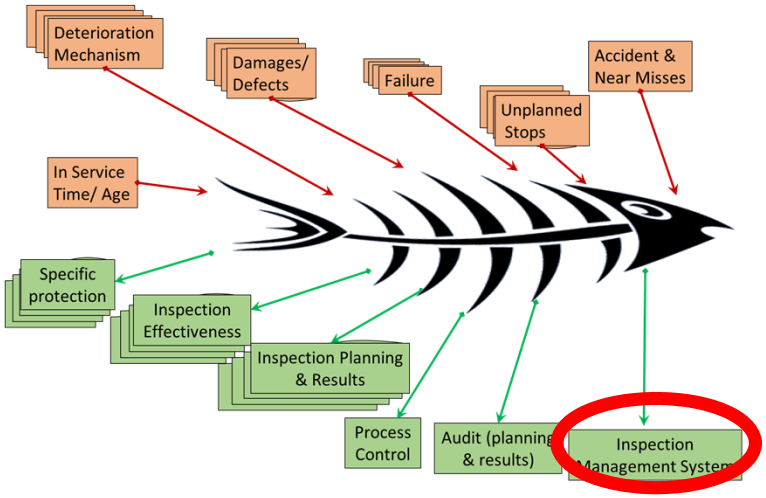
For any critical item

For establishment

Factor	Score	Value
Audits SMS	1 2 3 4	Average score: (i) % of minor non-compliances, (ii) % of major non-compliances
Inspection management	1 2 3 4	• compliant with legislation • RBI • updated after changes • periodically updated
Process control	1 2 3 4	• local control system • control system with data recording • data recording system with automatic blockage • IEC 61508 or IEC 61511

INSPECTION MANAGEMENT SYSTEM

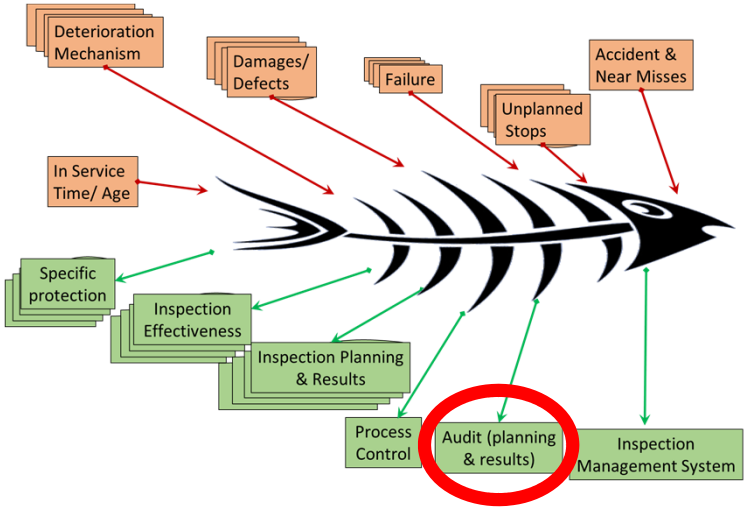
The factor wants to reward the adoption of risk-based management system and comply with industry standards



Score	Type of Management System
1	Basic Inspection Record
2	'Homemade' Risk Based Program
3	RBI (API 580; API581:2016, EEMUA 159:2017)
4	DYNAMIC RBI (API 584:2014) Certified RBI EN 16991:2018

AUDIT

It refers to audits on the entire safety management system. Audits are mandatory under the SEVESO legislation



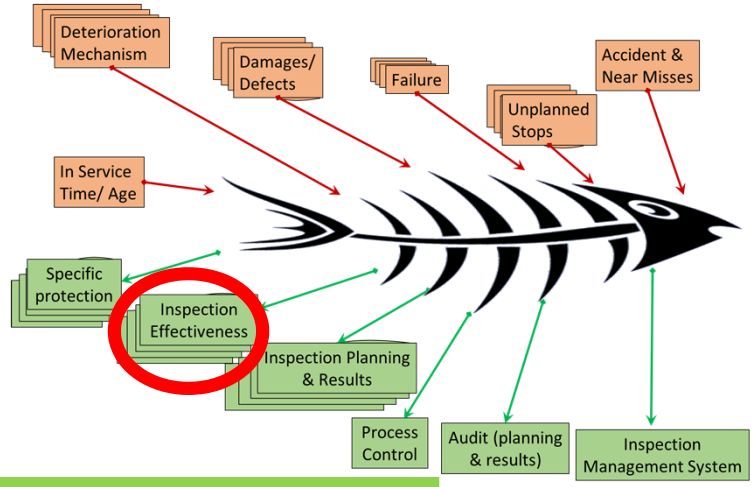
score	% major non-conformities
1	30.0%
2	20.0%
3	10.0%
4	5.0%

score	% minor non-conformities
1	20%
2	10%
3	5%
4	3%

INSPECTION EFFECTIVENESS

The factor rewards the probability of detecting the damage (extension, degree of coverage); as well as the qualification of inspectors

The factor is an average of sub-factors.



Score	Efficiency
1	Able to detect the damage in 50% cases
2	Able to detect the damage in 75% cases
3	Able to detect the damage in 90% cases
4	Able to detect the damage in almost all cases

Score	Inspector Qualification
1	competence/experience
2	standard ASNT
3	Qualification ISO 9712:2012 Livello 1/2
4	ISO 17020:2012 Qualification ISO 9712:2012 Livello 2/3

CONCLUSIONS

First research paper presented at CISAP Int. Conference sept. 2016

December 2016 the Ministry Steering Committee instituted a WG, with experts INAIL, ISPRA, ARPA, Unione Petrolifera, Federchimic. Scientific Supervision by University of Messina

March – July 2017 Guideline preparation

July- Dec. 2017 Testing (Tank Farm, Refinery, LPG depot)

Jan. 2018 FISHBONE Guideline internal release

April 2018 Official Publication on Ministry Website

June-Sep. 2018 Training in cooperation with Unione Petrolifera and Federchimica

2018-19 campaign, Upper-Tier Seveso establishments inspected using the Guideline

https://www.minambiente.it/pagina/documenti-di-indirizzo-linee-guida-o-altra-documentazione-di-interesse

Maria Francesca Milazzo, Paolo Bragatto
"A framework addressing a safe ageing management in complex industrial sites: The Italian experience in «Seveso» establishments"
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A framework addressing a safe ageing management in complex industrial sites: The Italian experience in «Seveso» establishments

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Loss of containment (LOC)
Inspection
Damage mechanism

ABSTRACT

In Europe, the Directive 2012/18/EU (Seveso III) strengthens the obligation to adopt a program assuring the integrity of critical equipment at major hazard establishments, by taking into account actual deterioration mechanisms (internal and external corrosion, erosion, thermal and mechanical fatigue, etc.). The program must cover all phases of the lifecycle and ensure a safe ageing of equipment, particularly when these are reaching the final stage of life. The effectiveness of the integrity program must be carefully assessed dutrig the audits planned by the establishment's operator as well as by inspectors on behalf of the Competent Authorities. The adoption of a Risk Based Inspection scheme provides a valuable help to face this matter. The operator is, anyway, required a considerable effort to face at least three issues related to: (i) the understanding of concurring physical and chemical phenomena; (ii) the management of information associated with each individual component and its history, (iii) the appropriate measurement, including acquisition and management of data. There is a considerable difficulty in understanding these issues during Seveso inspections and external audits, because time and resources are often limited. For this reason, models and methods supporting the definition of the ageing status and trend in industrial sites are needed. This paper analyses the main factors affecting ageing. A framework for "ageing" assessment in complex industrial sites, including "Seveso" establishments, is proposed; then, its validation, by means of data collected during a testing phase carried out in Italy, is also given.

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