

RBI
Risk Based Inspection



The Most Feature-Rich, Asset-Intelligent, RBI-Driven
Asset Integrity Management Solution Available



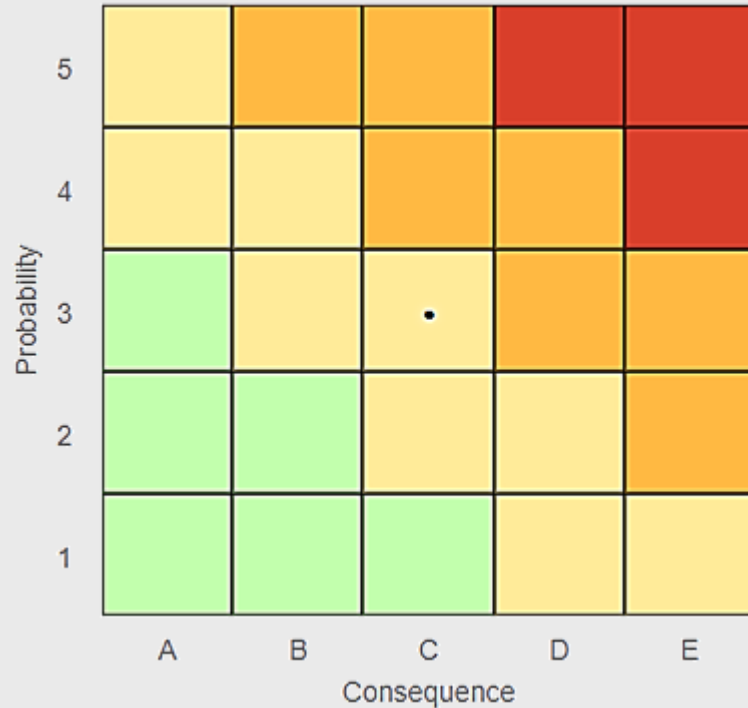


WHAT IS RBI?

The RBI (Risk-Based Inspection) is a process that assesses the industrial risk that can compromise the equipment in an industrial plant.

The RBI purpose is obtaining a proper Inspection Plan in terms of dates, NDT techniques and locations (when, how and where to inspect).

RISK CONCEPT

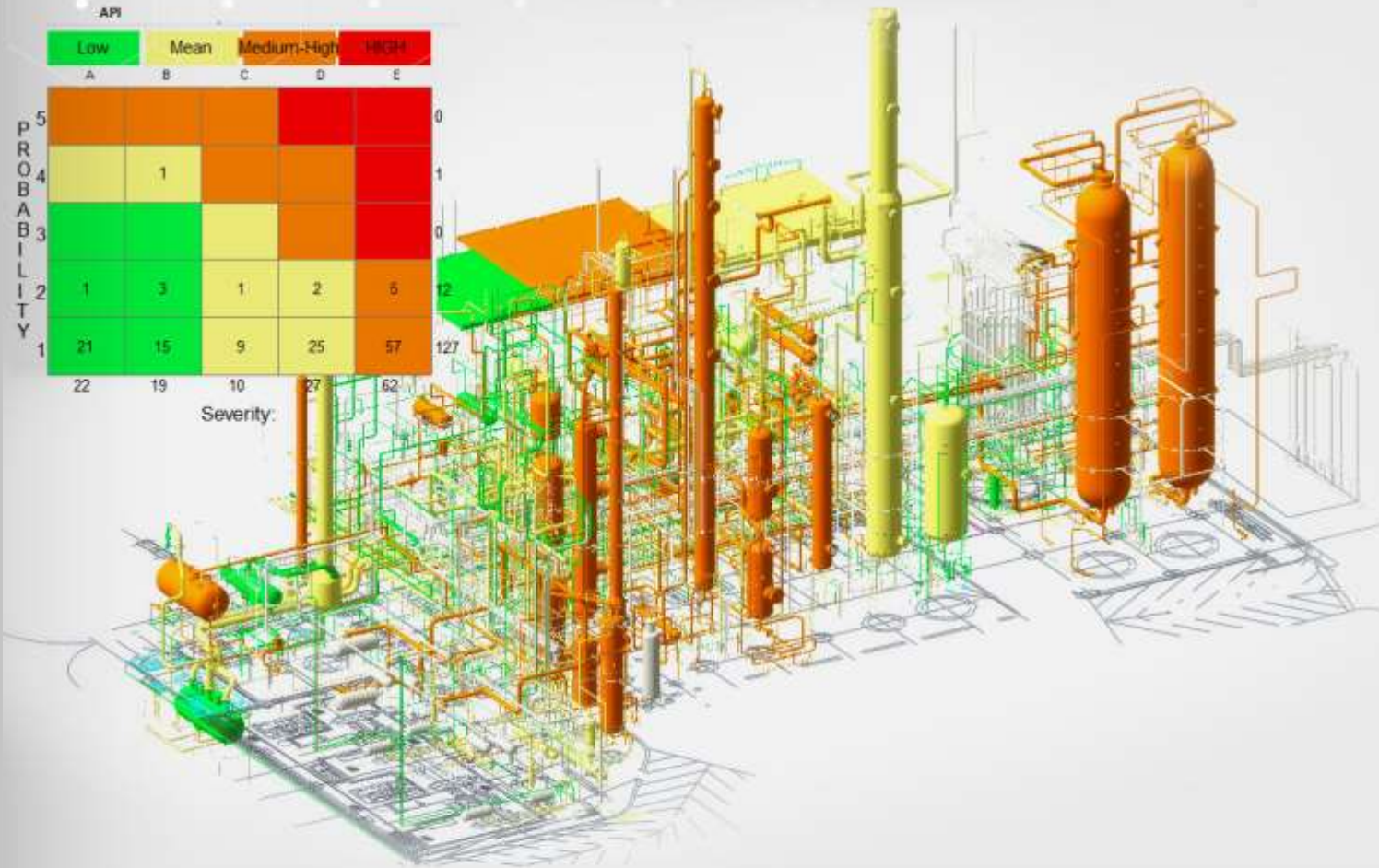


**RISK =
PROBABILITY X SEVERITY**

The corrosion risk is assessed through the combination of the corrosion probability and the overall consequence factor on the risk matrix.

ANTEA RBI

Automated Risk Based Inspection Calculation



ANTEA RBI

Qualitative, semi quantitative and quantitative RBI analysis based on various international standards as well as customized methodologies.

RISK EVALUATION

Evaluates the probability and severity of the actual and future risk in a plant and creates an inspection plan accordingly.

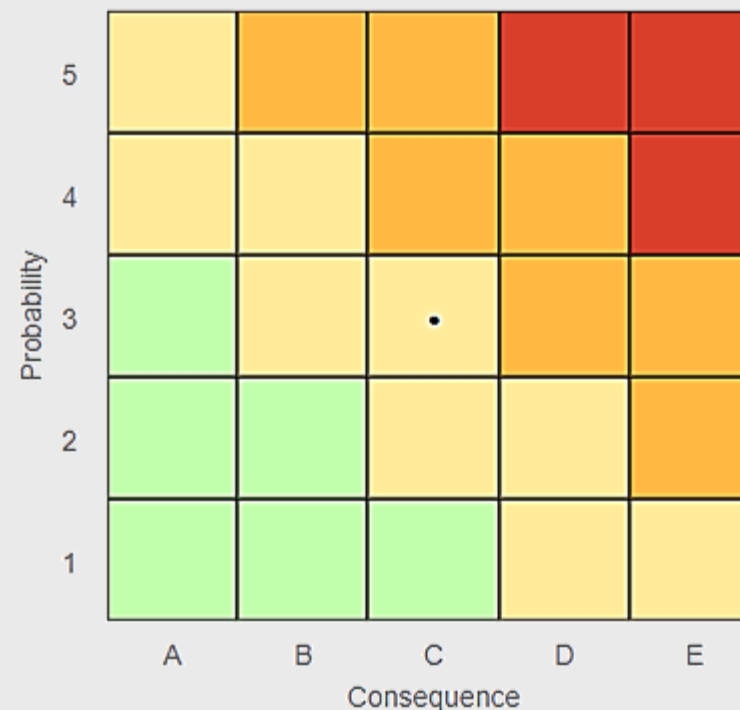
API 581 COMPLIANCE (Validated By Bureau Veritas)

Includes API 581 damage mechanisms for hundreds of assets; define custom damage mechanisms as needed.

ACTUAL AND FUTURE RISK

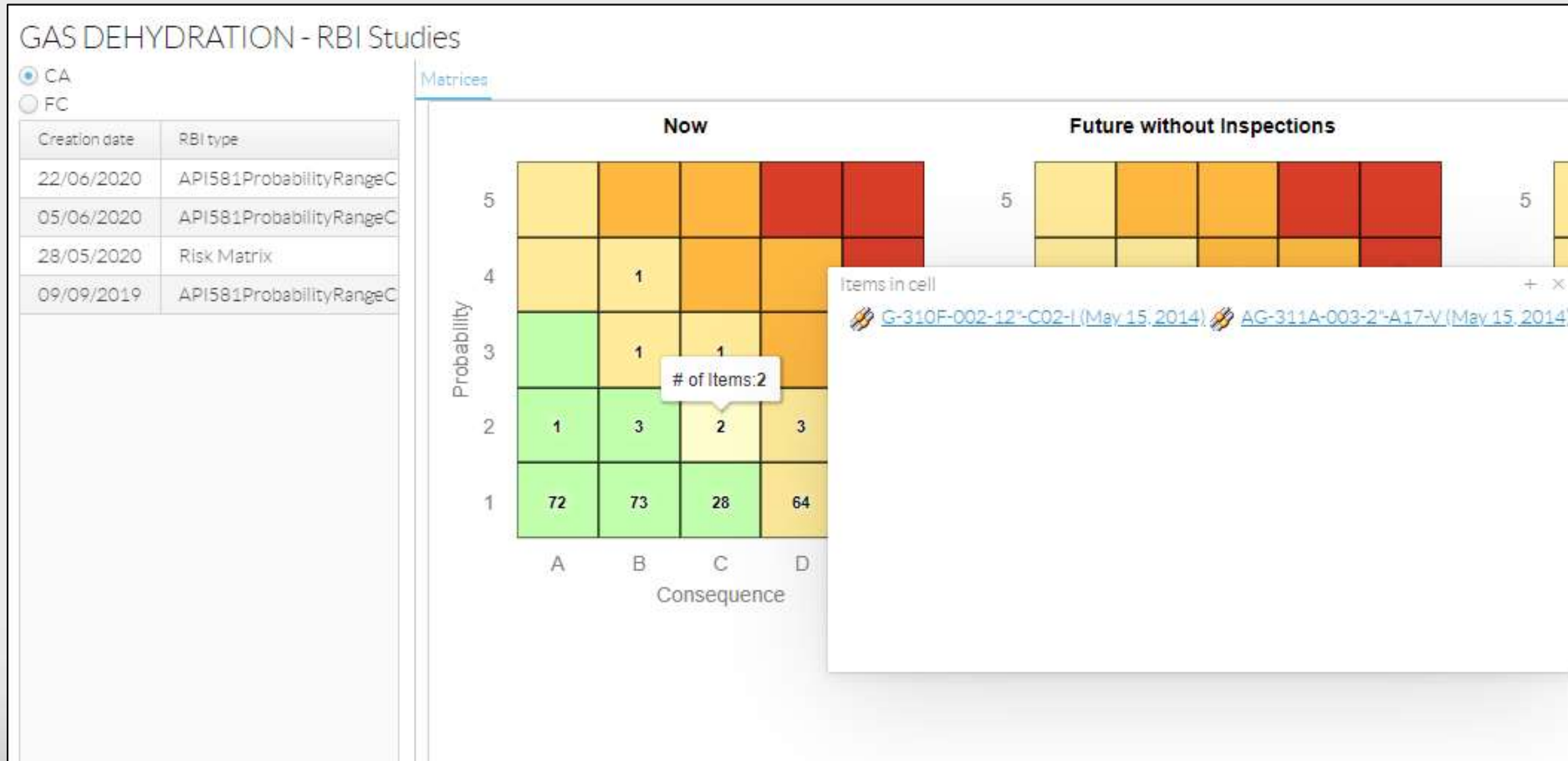
The RBI results of each item are displayed on the RBI matrix:

- actual risk level;
- future risk level with inspection (inspection plan considered);
- future risk level without inspection (inspection plan not considered);
- description of the inspection plan as a result of the RBI analysis.



RISK OVERVIEW

It is possible to visualize the number of items of a plant with the same level of risk and to select them directly on the matrix.



RISK PROJECTION



It is possible to compare the matrixes with all the items' risk levels in the future prevision (with or without inspection).

All the matrixes are interactive; the most critical items can be immediately identified and directly accessed in the database.

APPROACH

QUALITATIVE	<ul style="list-style-type: none">• Faster procedure• Low level of data detail• Typically qualitative results (Low, Medium, High Risk).
SEMI – QUANTITATIVE	<ul style="list-style-type: none">• More detailed data than qualitative analysis• Shortcut on quantitative analysis
QUANTITATIVE	<ul style="list-style-type: none">• Complex procedure• High level of data detail• Logic models• Typically quantitative results (Probability of Failure, Consequence of Area, Financial Consequence, Risk Value)

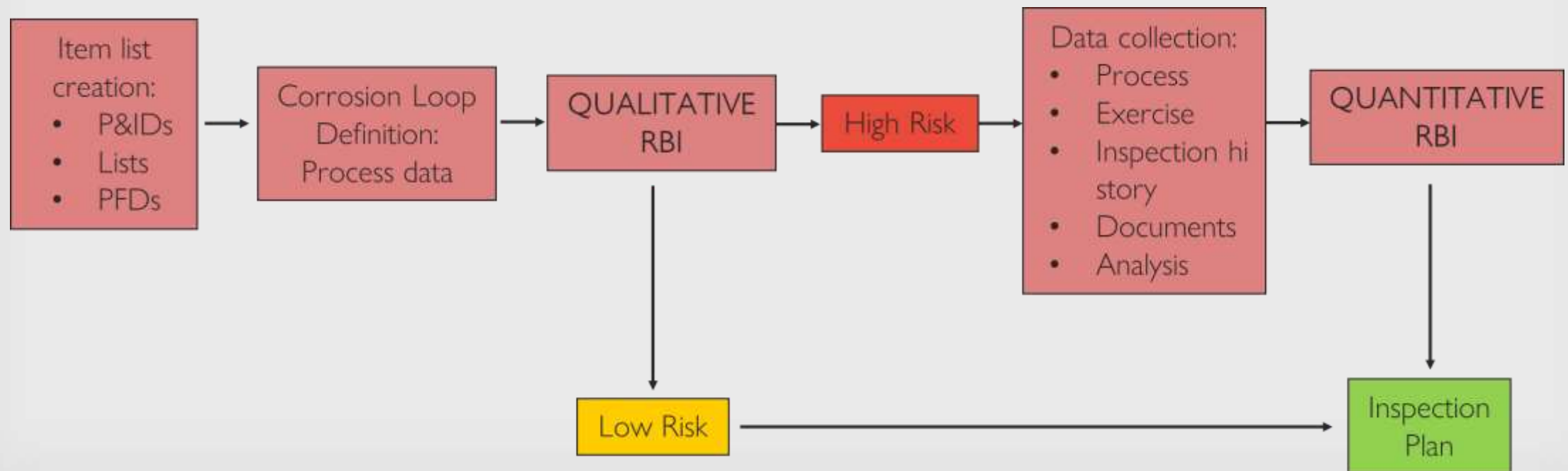
STANDARDS

QUALITATIVE	<ul style="list-style-type: none">• API 580 – 581 (rev. 1, 2, 3)• DNV-RP-G101 (for Offshore)• CEN/TC 319/WG 12 – Risk Based Inspection Framework (RBIF)• NACE standards• Customized methodology*
SEMI – QUANTITATIVE	<ul style="list-style-type: none">• NACE standards
QUANTITATIVE	<ul style="list-style-type: none">• API 581 (rev. 3)• Modules from DNV-RP-G101 (Probability and Corrosion Rates)• API 579 > Fitness For Services (FFS)• Determination Thickness min• NACE standards• Customized Damage Mechanism methodology *

*Customization: RBI can be based also on company's internal regulations at 2 different levels: qualitative methodology and additional modules for damage mechanisms.

RBI PROCESS

The RBI team chooses the proper approach (fully qualitative, fully quantitative, semi-quantitative or multiple-step approach) to perform the RBI analysis. An example of multiple-step approach is represented below:



CUSTOMIZATION

Import an external RBI Study

New Study

Current RBI Studies

Name
18-mag-2009
23-apr-2010
1-gen-2014
15-mag-2014
Analisi CLUSTER
test impianto 19
ABC
Studio RBI test
Studio Fermata 2020
MACO trial
rbridemo
Studio Separator on WHP, no H2S in Carbon Steel
User_Test_R4_01
Tank RBI Study
TEST
Risk analysis
Test Antea
Demo USA
Test_Cog
Tank Analysis
Antea Canada
COG_Risk_Analysis_R00.1

RBI Study | RBI Study Configuration | RBI Results

Demo USA

Select the item →

Configuration

Rules release 303 UoM System SI

Screening

PF FoC

Detailed Analysis

Type Pf = Api 581 Pf

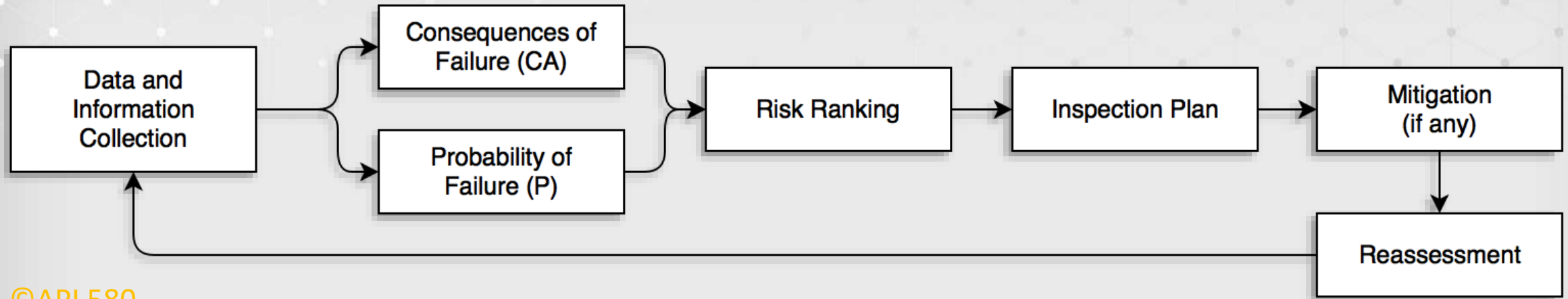
Mechanism	API 581	Can be in API	Included
▼ Api 581 Pf	✓		✓
▶ Df-SCC	✓		✓
Df-HTHA	✓		✓
Df-MFAT	✓		✓
Df-Brittle	✓		✓
Df-LIN	✓		✓
Df-THIN	✓		✓
Df-External	✓		✓
Df-HTHA (User can select the value)		✓	

Management of
RBI studies

Selection of the
RBI mechanism

Selection of
qualitative module

API RBI PROCESS



©API 580

Antea RBI has been assessed compliant against API 581 v.2016 methodology by Bureau Veritas. It supports the user during all steps of the RBI planning process, as indicated in API 581:

- accessing all the technical and inspection equipment data;
- the probability, the severity and the risk calculation for each equipment or component, according to API 581 standards;
- inspection creation and management;
- quick analysis of the equipment risk status and appropriate mitigation actions;
- much faster reassessment.





DATA ANALYSIS AND LOADING

Antea RBI provides an immediate support when checking the data required for the calculations. Details are divided in different sheets depending on the typology (results, basic data or damage mechanisms, etc.). Data can be manually inserted into the table or directly imported from Excel files, loading huge quantities of data.

RBI Study RBI Study Configuration **RBI Results**

Import ▾ Change State ▾ Clear filters ✕ Print 🖨️ Download XLS 📄 25 per page (4 total) ⏪ ⏩ 1 / 1 ⏴ ⏵ 🟢 🟢

Results Basic Information Api 581 CA Api 581 FC Api for PRD Df-Brittle Df-External Df-HTHA Df-LIN Df-MFAT Df-SCC Df-THIN Api 581 2000 Screening OCC Api 581 2000 Screening Pf

State	RBI Date	Equipment	Component	RBI Part	Screening-Risk Matrix	Risk Matrix CA	Risk Region CA	Risk Matrix F...	Risk Region FC	Pf
Open	10/08/2020	 05-NG-130-0-001-6'-03D-V/B		Straight Pipe		4D	High			0.022742
Open	10/08/2018	 310-AVE-051		Top column		3C	Medium			0.0005149
Open	10/08/2018	 310-AVE-051		Middle column		3B	Medium			0.0003484
Open	10/08/2018	 310-AVE-051		Bottom column		1B	Low			0.0000005

Probability of failure (P) are calculated in 3 ways.

1. Sum of different probabilities

$$P = \sum_1^n P_i$$

2. Maximum between probabilities

$$P = \max(P_1; P_2; \dots; P_n)$$

3. API 581 probability

$$P(t) = gff * D_{f-total} * F_{MS}$$

Depending on the thinning type (local or generalized), the damage factor is calculated through the following formulas:

Local:
$$D_{f-total} = \max[D_{f-gov}^{thin}, D_{f-gov}^{extd}] + D_{f-gov}^{scc} + D_f^{htha} + D_{f-gov}^{brit} + D_f^{mfat}$$

Generalized:
$$D_{f-total} = D_{f-gov}^{thin} + D_{f-gov}^{extd} + D_{f-gov}^{scc} + D_f^{htha} + D_{f-gov}^{brit} + D_f^{mfat}$$

ADDITIONAL MODULES

Damage Mechanism	Complete calculation	API 581	Add or Modify Module	Warning	NOTE / Ref.
CO ₂	X	X	X		Modify as M506 Norsok (formation water).
MIC	X		X		DNV RP G101
H ₂ S corrosion (Oxygen Corrosion)	X		X	X	Add limit as (CO ₂ influence) Norsok M506 DNV RP G101
Erosion-Corrosion	X		X		API RP14E. PoF = 1 or 0 if velocity is more or less critical velocity.
Elemental Sulphur				X	Warning if influences on SSC.
Galvanic Corrosion				X	Warning on conditions
Localized Pitting & Crevice	X		X		DNV RP O501 / (Norsok M001)
Sand Erosion	X		X		DNV RP G101 / DNV RP O501
General SCC	X	X	X		Manual inserting of Severity Index in API 581 stress corrosion cracking calculation
Sulphide Stress Cracking	X		X		PoF = 0,1 or 1 if compliant with NACE MR0175/ISO 15156
HIC	X		X		PoF = 0,1 or 1 if compliant with NACE MR0175/ISO 15156
Mercury				X	Warning on conditions
General External Cr	X	X	X		Manual inserting of external corrosion rate in API 581 external and corrosion under insulation calculation

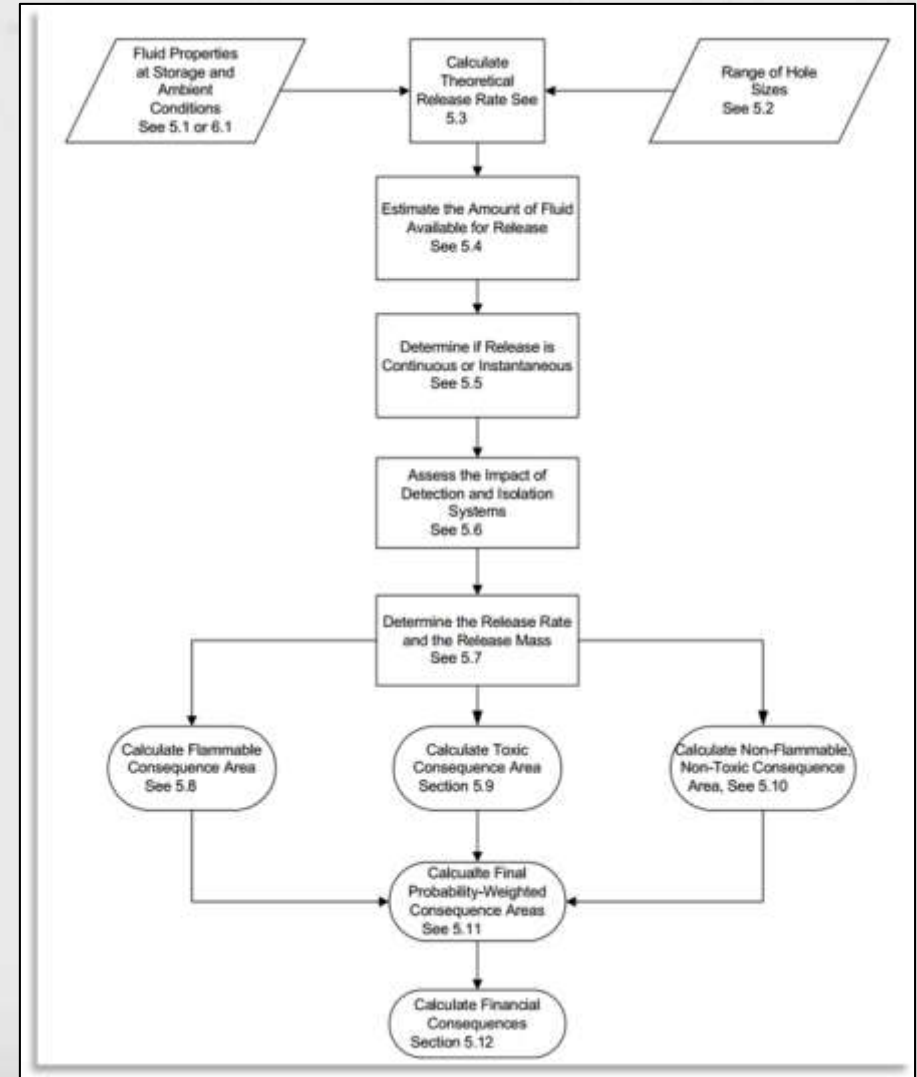
The additional probability quantitative modules (extra API 581) available in Antea RBI are listed in the table below. Antea can implement new modules meeting the specific requests of customers.

Consequence of Failure (CF) is calculated using different modules. The most used module is API 581 consequence calculation.

It calculates the flammable, toxic and non-flammable/non-toxic consequence, depending on the fluid type.

It can be assessed as Consequence Area (CA) or Financial Consequence (FC).

See the diagram on the right for more details on API 581 consequence calculation.



RISK CALCULATION

The Risk is calculated considering the Probability and Severity factors.

The Consequence Area is calculated through the following formula:

$$R(t) = P(t) * CA$$

while the Financial Consequence is calculated through:

$$R(t) = P(t) * FC$$

The Risk Matrix presents the value of Consequence on the horizontal axis and the value of Probability on the ordinate axis.

Each component has a position on the matrix.

5					
4		1			
3		1	1		
2	1	3	2	3	10
1	72	73	28	64	84
	A	B	C	D	E

INSPECTION PLAN

Antea RBI supports the user to create a proper Inspection Plan by selecting between two options:

- Frequency based method

The inspection frequency is assigned to an item based on its position on the risk matrix, and the date is calculated from the last inspection performed.

It is also possible to assign a list of activities.

- Date based method

In accordance to the API 581 standards, the software evaluates the future risk and provides an inspection plan if requested.

The variables influencing the risk are:

- time since the last inspection date for each damage mechanism;
- the inspection effectiveness for each damage mechanism.

It is necessary to define a limit risk value (Risk Target) not to be exceeded.

5	5	5	2	1
8	8	5	5	2
10	10	8	5	2
10	10	8	8	5
10	10	8	8	5

INSPECTION PLAN

API 581

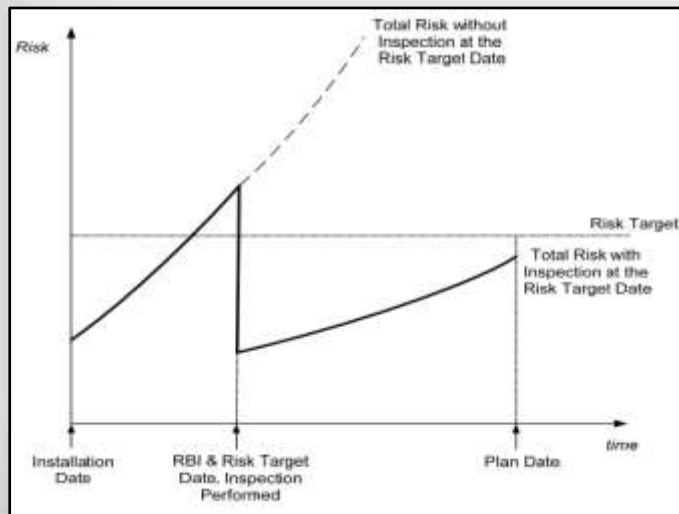
The results of the RBI analysis are aimed to establish:

- the inspection date;
- the inspection result (type of inspection, inspection locations and details).

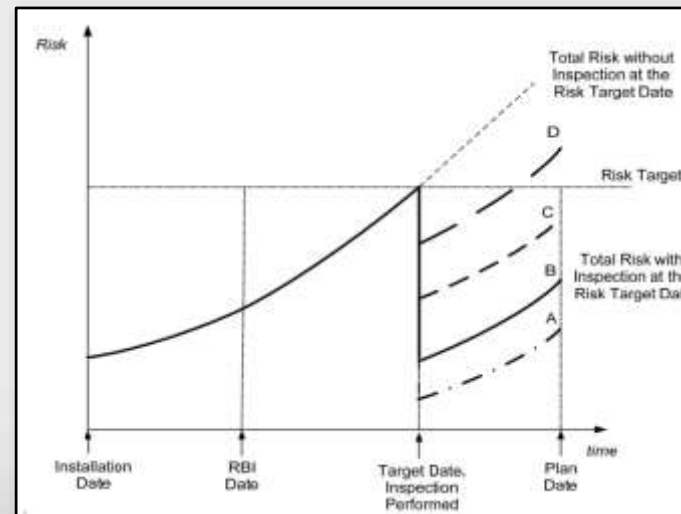
If the risk at the inspection date is lower than the Risk Target, the software calculates the future date when the risk will reach the limit. This is a recommended date, in order to perform a proper inspection (Target Date). The RBI evaluation time limit is the Plan Date, when the risk is planned. It could be a shutdown, a mandatory inspection or just a convenient date.

If the RBI date is later than the Target date, an immediate inspection is recommended.

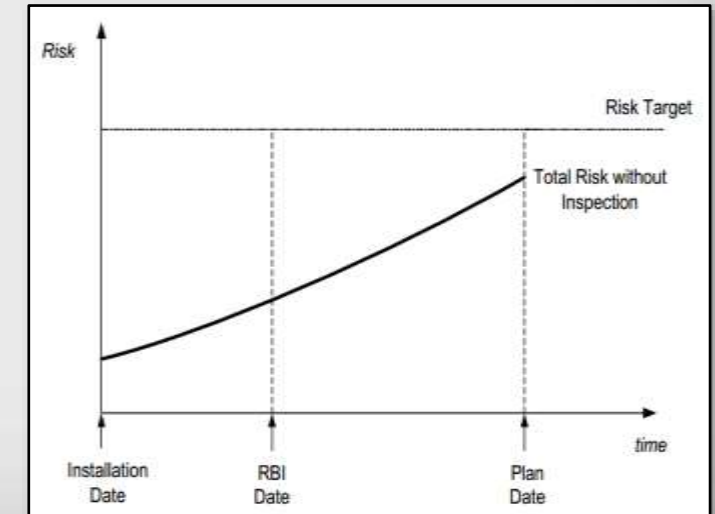
If the RBI date is earlier than the Target date and the risk limit is not reached before the Plan Date, an inspection is not recommended.



Case 1



Case 2



Case 3

INSPECTION EFFECTIVENESS

API 581 provides five levels of Inspection Effectiveness. See tables below for general reference and local thinning example.

In order to define the Inspection effectiveness for each damage mechanism, different approaches can be adopted:

- **Manual Inspection Planning:** it is possible to manually customize the inspection plan, setting the effectiveness for each damage mechanism and simulating the risk at the Plan date;
- **Automatic Inspection Planning - Plan Mode:** this procedure automatically recommend an inspection plan according to the API 581 guidelines. The procedure identifies the worst possible damage mechanism and suggests the lowest inspection effectiveness that results in a risk under the target at the Plan date;
- **Automatic Inspection Planning - Date Mode:** this procedure enables to set a hypothetic inspection plan and calculates the future date when the risk limit will be reached.

Inspection Effectiveness Category	Inspection Effectiveness Description	Description
A	Highly Effective	The inspection methods will correctly identify the true damage state in nearly every case (or 80-100% confidence).
B	Usually Effective	The inspection methods will correctly identify the true damage state most of the time (or 60-80% confidence).
C	Fairly Effective	The inspection methods will correctly identify the true damage state about half of the time (or 40-60% confidence).
D	Poorly Effective	The inspection methods will provide little information to correctly identify the true damage state (or 20-40% confidence).
E	Ineffective	The inspection method will provide no or almost no information that will correctly identify the true damage state and are considered ineffective for detecting the specific damage mechanism (less than 20% confidence).

Inspection Category	Inspection Effectiveness Category	Intrusive Inspection Example ^{1,2,3,4}	Non-intrusive Inspection Example ^{1,2,3,4}
A	Highly Effective	For the total surface area: 100% visual examination (with removal of internal packing, trays, etc.) AND 100% follow-up at locally thinned areas	For the total suspect area: 100% coverage of the CML's using ultrasonic scanning or profile radiography
B	Usually Effective	For the total surface area: >75 % visual examination AND 100% follow-up at locally thinned areas	For the total suspect area: >75% coverage of the CML's using ultrasonic scanning or profile radiography
C	Fairly Effective	For the total surface area: >50% visual examination AND 100% follow-up at locally thinned areas.	For the total suspect area: >50% coverage of the CML's using ultrasonic scanning or profile radiography
D	Poorly Effective	For the total surface area: >20% visual examination AND 100% follow-up at locally thinned areas	For the total suspect area: >20% coverage of the CML's using ultrasonic scanning or profile radiography
E	Ineffective	ineffective inspection technique/plan was utilized	ineffective inspection technique/plan was utilized

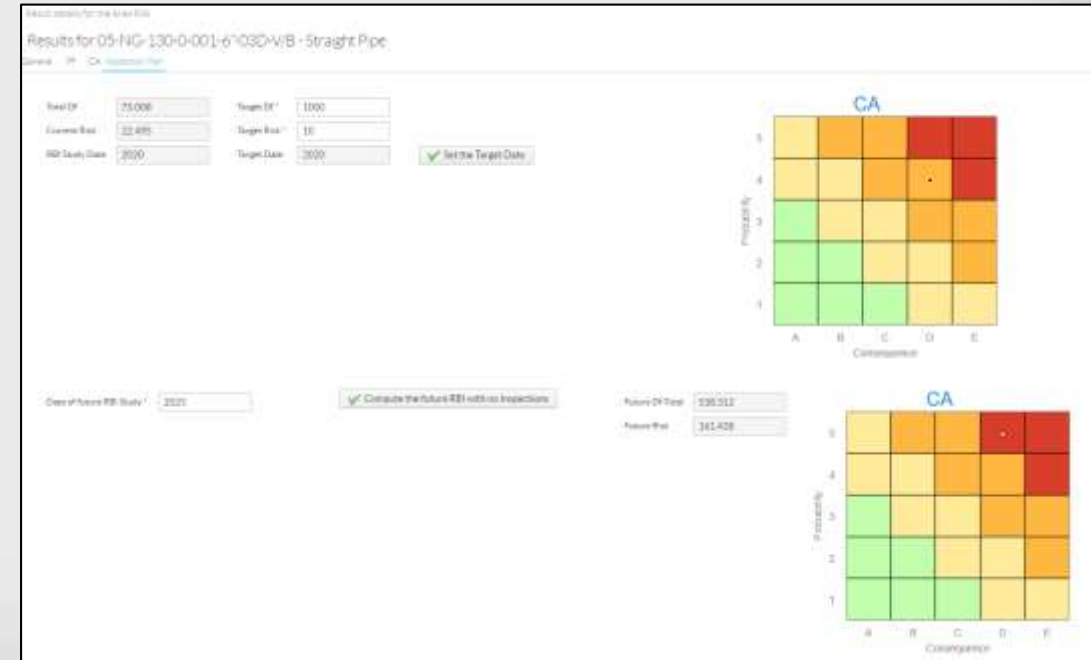
MITIGATION AND REASSESSMENT

All the RBI study details are stored in the software complete of inspection, maintenance and technical data. The results are accessed by the technical staff in order to provide any mitigation equipment. The Reassessment phase consists of the previous RBI data recovery and changes that the equipment has undergone.

Results for 05-NG-130-0-001-6"03D-V/B - Straight Pipe

Name	Value	Unit	Appl.	Name	Value	Unit
PI	0022			NATURAL	Type 320	
PIADI	0022			MATCAT	Automatic stainless ste.	
PIEVAL	78.008			EQVALT	Pipes and tubes	
TIREDTHICK	GENERAL			COMPCT	Pipe thickness	
DI-THICK	NaN			Phase factor	7	
DI-THICKB	NaN			Cladding	no	
DI-THICKC	NaN			TAV		1000
DI-THICKD	NaN			V		100
DI-THICKE	75			AGL	How acceptable is the	
DI-THICKF	0008			THRE THICK BASE VALUE	GENERAL	
RIG	8.908			Corrosion Mechanism Identification	Yes	
OFF	3.04E-5			On-Isolate	No	
Characteristic W				On-Valve		100%
ESUNDNESS INDEX				Streaming Activation	Yes	
				H2O Presence	Yes	
				H2O Presence	Yes	
				pH-H2O		8.7
				Corrosion		30
				API Corrosion presence value		
				OT		210

Calculation Mask



Inspection Planning

RBI INTEGRATION



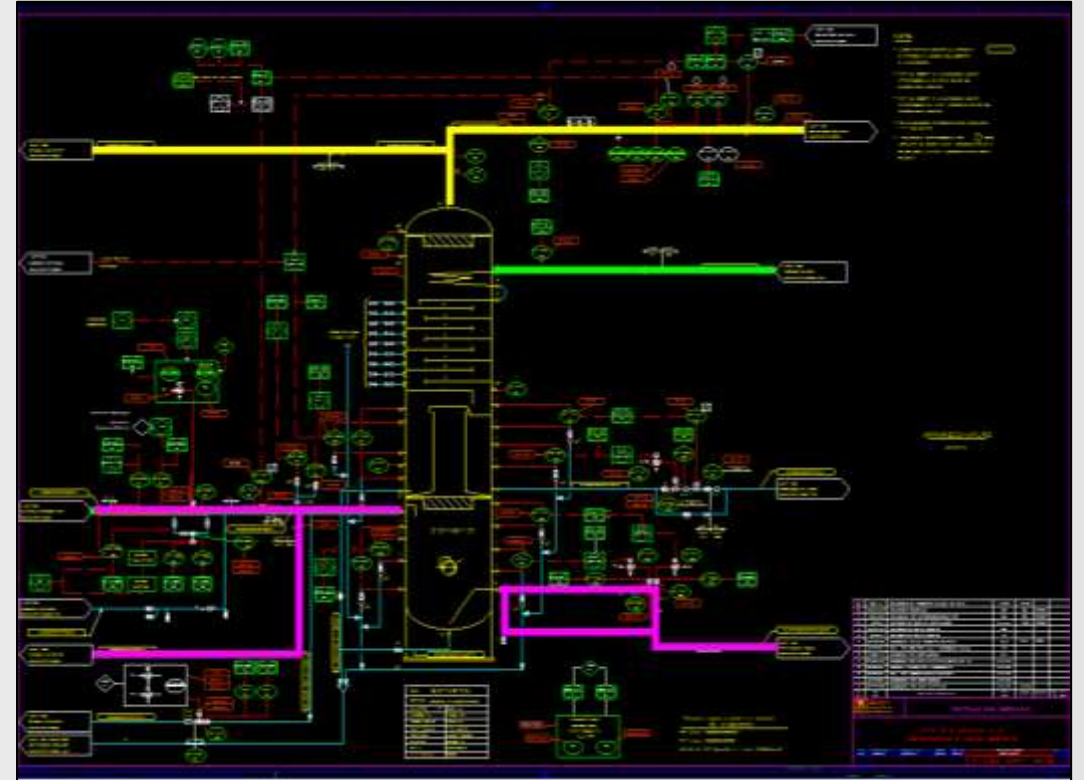
The results from Antea RBI are totally integrated with the IDMS application. The same interface presents information concerning details of the damage mechanisms involved, inspection sheet and recommended inspection techniques, equipment 3D location, inspection history, datasheet, activity plan, document management.

DATABASE AND CORROSION LOOPS

Antea platform stores all the technical and inspection data.

The software easily and quickly locates the data necessary for the RBI (operating manuals, P&IDs, technical drawings, piping classes, fluid properties, design and process conditions, inspection history, etc.).

The items are divided in Corrosion Loops (circuits) that are represented on the P&IDs. The Corrosion Loops are created according to condition, fluid, material and damage mechanism.

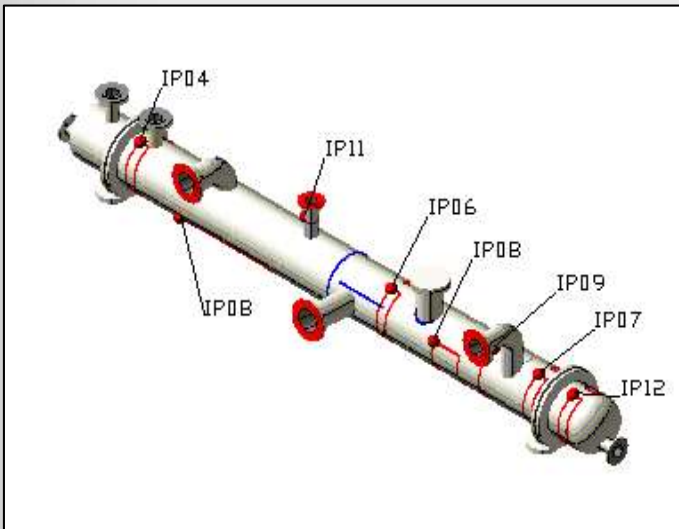


FEATURES

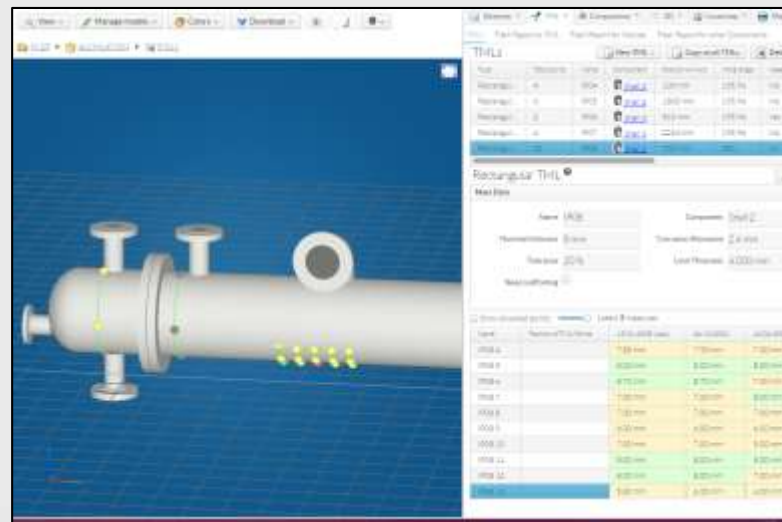
The software supports all the inspection activities, from the preparation step to the consultation and deadlines management.

The following useful features are available:

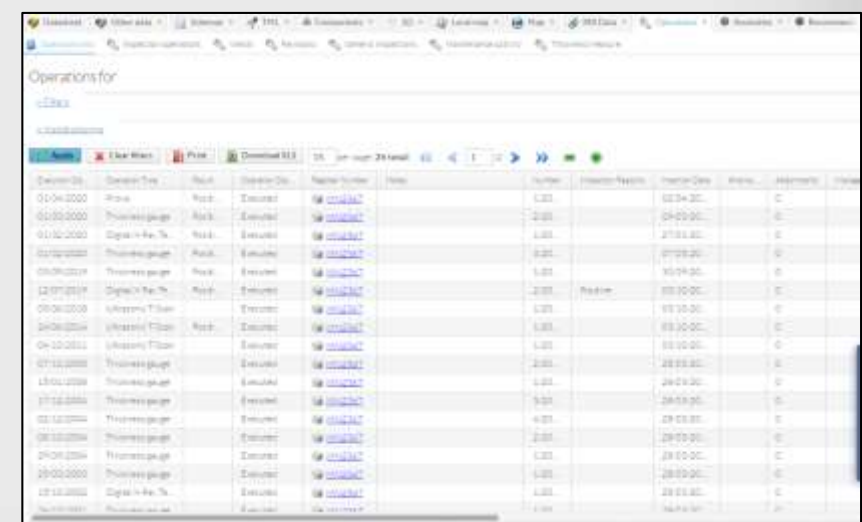
- Thickness Preparing Module;
- integrated inspection consultation;
- inspection deadlines and reports management.



Equipment 3D layout



Graphic visualization of the thickness measurements




Inspection Report

THICKNESS PREPARING MODULE

Once the RBI analysis is completed, the user can create the Thickness Preparing Module, very helpful for the inspection staff.

The areas to be inspected can be quickly identified and the 3D model enables to easily locate the areas.

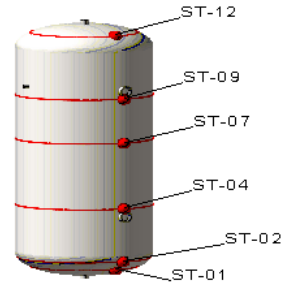
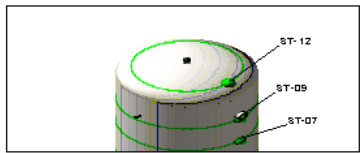
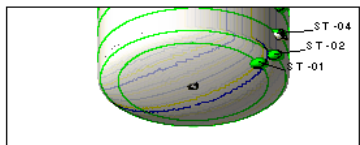
The module layout can be saved and used for all the future inspection activities.



Thickness gauge module

Page: 1 of 2
 Cert. N.:

Plant: DEMO FACTORY		Equipment: AVE002		Volume: 900,00 lt.	
Register N.: 300115-CR		Serial N.: 117993		Manufacturer: S.I.O.	
Plant id		Survey company		Operator:	
				Supervisor	
Material	Inst	Probes	Coilings	Calibration	Temp
19					

General data (mm)										Survey values (mm)									
TML	TR	Element	Mat.	St.	N. Th.	C.a.	V.tot.	L. th.	Mb.	u.1	u.2	u.3	u.4	u.5	u.6	u.7	u.8	u.9	u.10
ST-01	S	Fofofo Inf.	19	1	4,00	0,00	0,00	4,00	5,00	View data at the end of TML: If t									
ST-02	S	Fofofo Inf.	19	1	4,00	0,00	0,00	4,00	4,50	View data at the end of TML: If t									
ST-04	S	Matefo	19	1	4,00	0,00	0,00	4,00	4,10	View data at the end of TML: If t									
ST-07	S	Matefo	19	1	4,00	0,00	0,00	4,00	4,10	View data at the end of TML: If t									
ST-09	S	Matefo	19	1	4,00	0,00	0,00	4,00	4,00	View data at the end of TML: If t									
ST-12	S	Fofofo Sup.	19	1	4,00	0,00	0,00	4,00	5,10	View data at the end of TML: If t									

ST-01 - Fofofo Inf.											
R 1	C 1	C 2	C 3	C 4	C 5	C 6	C 7	C 8	C 9	C 10	C 12

ST-02 - Fofofo Inf.											
R 1	C 1	C 2	C 3	C 4	C 5	C 6	C 7	C 8	C 9	C 10	C 12

ST-04 - Matefo											
R 1	C 1	C 2	C 3	C 4	C 5	C 6	C 7	C 8	C 9	C 10	C 12

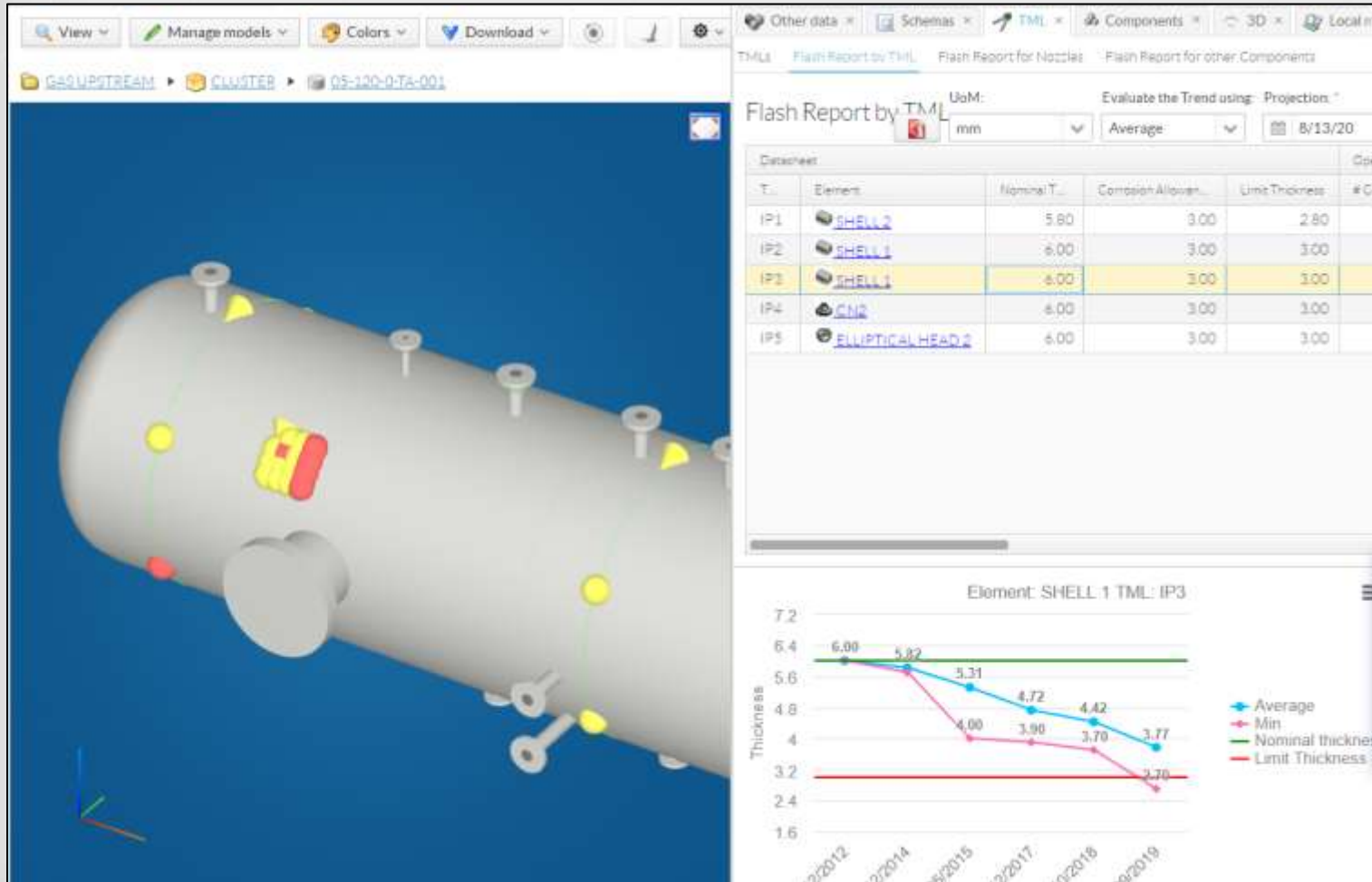
ST-07 - Matefo											
R 1	C 1	C 2	C 3	C 4	C 5	C 6	C 7	C 8	C 9	C 10	C 12

Operator:

Inspection-maker:

Inspection authority:

INSPECTION HISTORY



The Inspection History locates the critical areas, analyzes the corrosion trends, etc.

Different types of inspections can be stored, such as:

- Thickness measurements
- Radiographies
- Visual tests

DEADLINES MANAGEMENT

Multiple Scheduler

Search: []

Actions: Add, Overwrite, Print, Download XLS

Name	Frequency	Description	Simple Task	Status	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
[]	2 days		Visual Internal Inspection	In the year								
[]	2 days		Complete Thickness Inspection	In the day								
[]	2 days		Visual Inspection	In the day								
[]	2 days		Visual Internal Inspection	In the day								
[]	2 days		Visual Internal Inspection	In the day								
[]	1 day		Recommissioning	In the day								
[]	2 days		Visual Inspection	In the day								
[]	15 hours	Testing transmitters readings UT ins.	Complete Thickness Inspection	In the day								
[]	1 hour		Ultrasonic Thickness Measurement	In the day								
[]	2 days		Complete Thickness Inspection	In the day								
[]	1 hour		Recommissioning	In the day								
[]	2 days		Complete Thickness Inspection	In the day								
[]	2 days		Backup Inspection	In the day								
[]	2 days		Ultrasonic Thickness Measurement	In the day								
[]	2 days		Visual Inspection	In the day								
[]	2 days		Mandatory inspection	In the day								
[]	1 hour		Recommissioning	In the day								
[]	15 hours		Complete Thickness Inspection	In the day								

Activity Plan

Operations for

Search: []

Actions: Apply, Clear filters, Print, Download XLS

Execution Date	Device Type	Point	Detection Date	Report Number	Units	Status	System/Process	Interval Date	Alarm	Assignment	Change
01/04/2020	Probe	Point	Execute	[]				02/04/20			
01/03/2020	Thickness gauge	Point	Execute	[]				04/03/20			
01/02/2020	Digital In-Rule	Point	Execute	[]				27/01/20			
01/01/2020	Thickness gauge	Point	Execute	[]				07/01/20			
03/04/2014	Thickness gauge	Point	Execute	[]				30/04/20			
02/07/2014	Digital In-Rule	Point	Execute	[]			Boiler	01/07/20			
01/04/2014	Ultrasonic Transducer	Point	Execute	[]				01/04/20			
24/04/2014	Ultrasonic Transducer	Point	Execute	[]				01/04/20			
04/10/2011	Ultrasonic Transducer	Point	Execute	[]				01/10/20			
07/01/2008	Thickness gauge	Point	Execute	[]				24/01/20			
19/01/2004	Thickness gauge	Point	Execute	[]				24/01/20			
07/01/2004	Thickness gauge	Point	Execute	[]				24/01/20			
02/12/2004	Thickness gauge	Point	Execute	[]				24/01/20			
08/01/2004	Thickness gauge	Point	Execute	[]				24/01/20			
29/04/2004	Thickness gauge	Point	Execute	[]				24/01/20			
25/03/2003	Thickness gauge	Point	Execute	[]				24/01/20			
15/10/2002	Digital In-Rule	Point	Execute	[]				24/01/20			
04/07/2002	Thickness gauge	Point	Execute	[]				14/07/02			

Inspection Report Summary

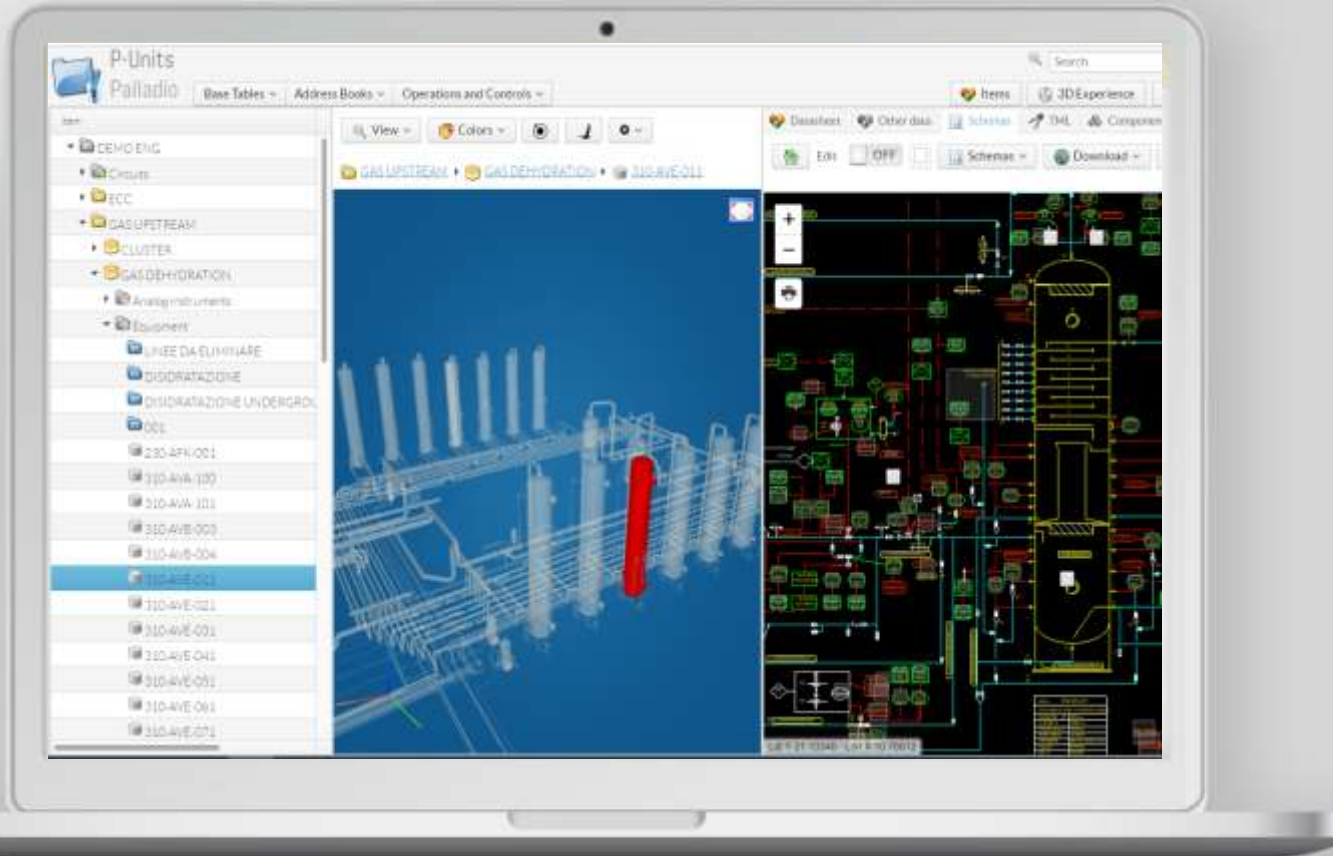
All the mandatory and the RBI deadlines can be managed in Antea platform through the Activity Plan tool.

The Activity Plan features an alarm function that highlights the expiring dates and a planner that optimizes the yearly activities.

In the Inspection Report Summary it is possible to manage the reports and the maintenance activities provided (Short and Long Term Actions).

THE ANTEA ADVANTAGE

The Power of A Fully Digitized Plant, At Your Fingertips



BETTER DECISIONS, FASTER

Quickly find and access all data in context from one intuitive visual interface.

INSTANT AUDIT READINESS

Instantly generate audit reports using up to the minute inspection data and RBI calculations.

AUTOMATED RBI COMPLIANCE

The only API 581 compliance engine approved and utilized by Bureau Veritas. With API 581 damage mechanisms for hundreds of assets.

CONNECTED WORKER

Enable the field staff with the same data and tools used in the back office. Gain real-time updates in the back office from completed field operations.



33 YEARS OF EXCELLENCE

The Antea platform is firmly established as the global leader in asset integrity management. With billions in chemical, petrochemical, power and utility facility assets managed around the world.



Supervisor	Alberto Mura		
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Revisions			
R00	17/08/2020	Diletta Realdon	First version
R01	21/11/2022	Diletta Realdon	Update few details
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