

Temporary Clamp Management e-TCM (Shark tank winner 2020)

BU owner: <T-II and TP-PM>

Present date: DD MMM YYYY



Agenda

- **Executive Summary**
- **Cost and Benefit**
- **Initial Study Result (research / hackathon)**
- **Implementation scope and approach**
- **Timeline**
- **Risk Assessment**
- **Vendor survey and comparison**
- **Team Organization**



Temporary Clamp Management (eTCM)

Implement Location
X-MN/X-OP/ T-II/TP-PO

Project Size
Medium

WHY: Background

Clamp is the best repair method for a maintenance engineer which prefers to repair any leakages to prevent an expensive and unwanted shutdown. However, its improper management can make a lack of monitoring and tracking of online leak sealing points causing an effect on its maintenance plan, trouble, and finally met the incident. So, this system is able to provide the leak sealing location mapping and risk assessment leading to effective maintenance planning, inspection and monitoring.

WHAT: Project Objective/Goal

1. Developing the novel application of systematic approach for managing an online-leak sealing point against the risk assessment with a smart reporting.
2. Improving the capability of maintenance work and inspection task planning.
3. Reducing the possibility of unplanned shutdown caused by a loss of containment through monitoring program.

HOW: Implementation approach

- Creating the concept of tracking system, risk assessment and reporting.
- Developing the Online leak-sealing Management System (OMS) program as per the concept.
- Selecting the pilot plant to implement OMS program against the existing online leak-sealing clamp.
- Implementing to all BU (Go-live)

WHO: Project Organization

Project Sponsor	Thaworn K. T-II/ Chatree Sa. TP-PM
Project Owner	Palakorn Sat. T-II-IP2
Stakeholders	Plant Operation, Plant Technic, Plant Maintenance and Inspection Department, Turnaround, Warehouse, Project

WHAT: Cost & Benefits

Financial Benefits

Total Investment (MB)	Benefit Category	IL2 (MB)	Payback Period
2.5 (CAPEX 2 MB)	Direct benefit: Saving >10MB/year product loss Indirect benefit: Saving unplanned S/D cost	xx	< 1 year

Non-Financial Benefits

Category	Description
Employee Satisfaction	Effective online-leak sealing tracking for improving maintenance work planning
Digital Culture	New ways of working as a digital leader
Customer Satisfaction	Unplanned shutdown prevention
Other i.e. Reputation/Regulatory / Safety	A loss of containment prevention

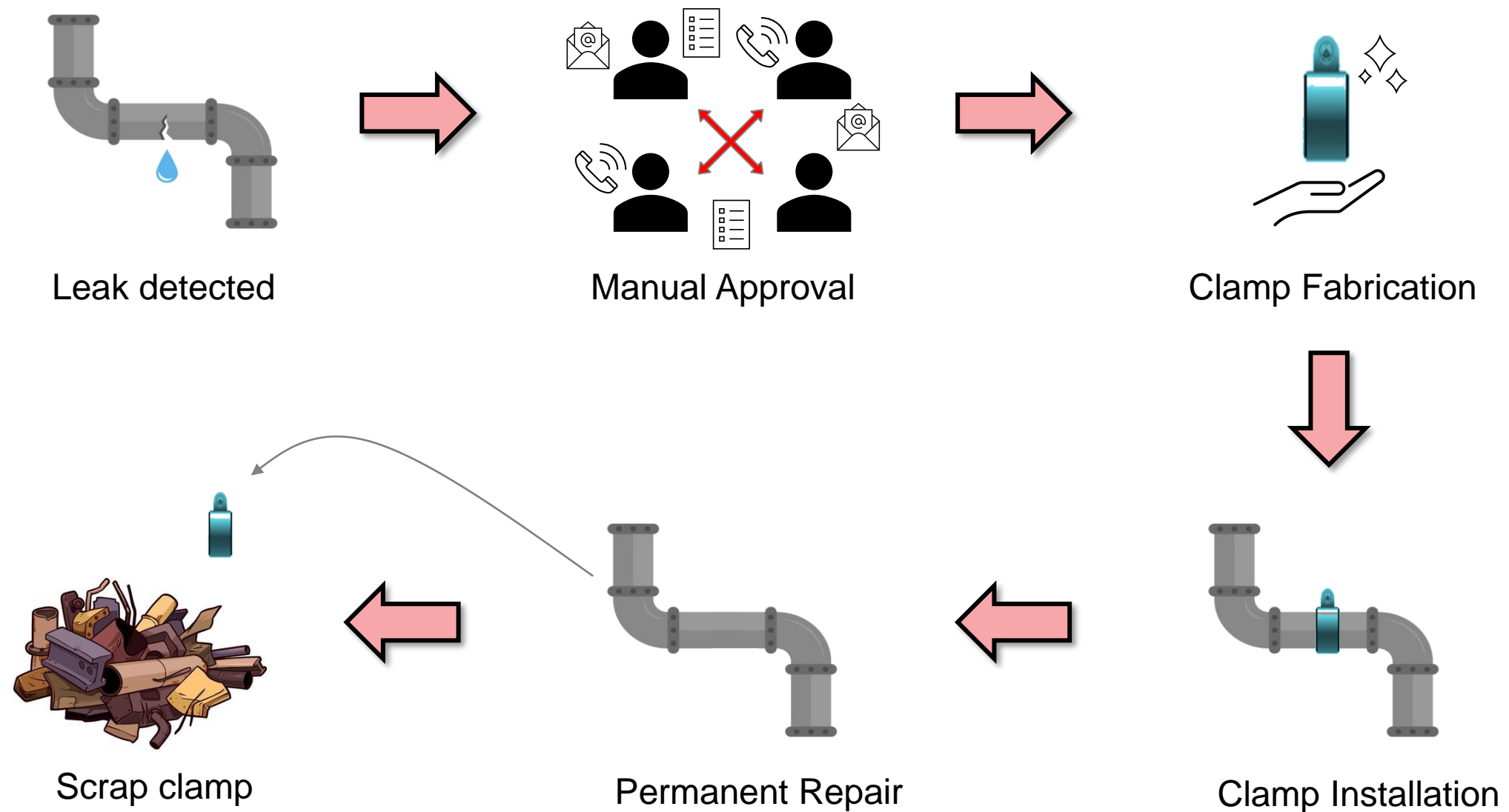
WHEN: Timeline

Start – End: Jan 2021 – Dec 2021

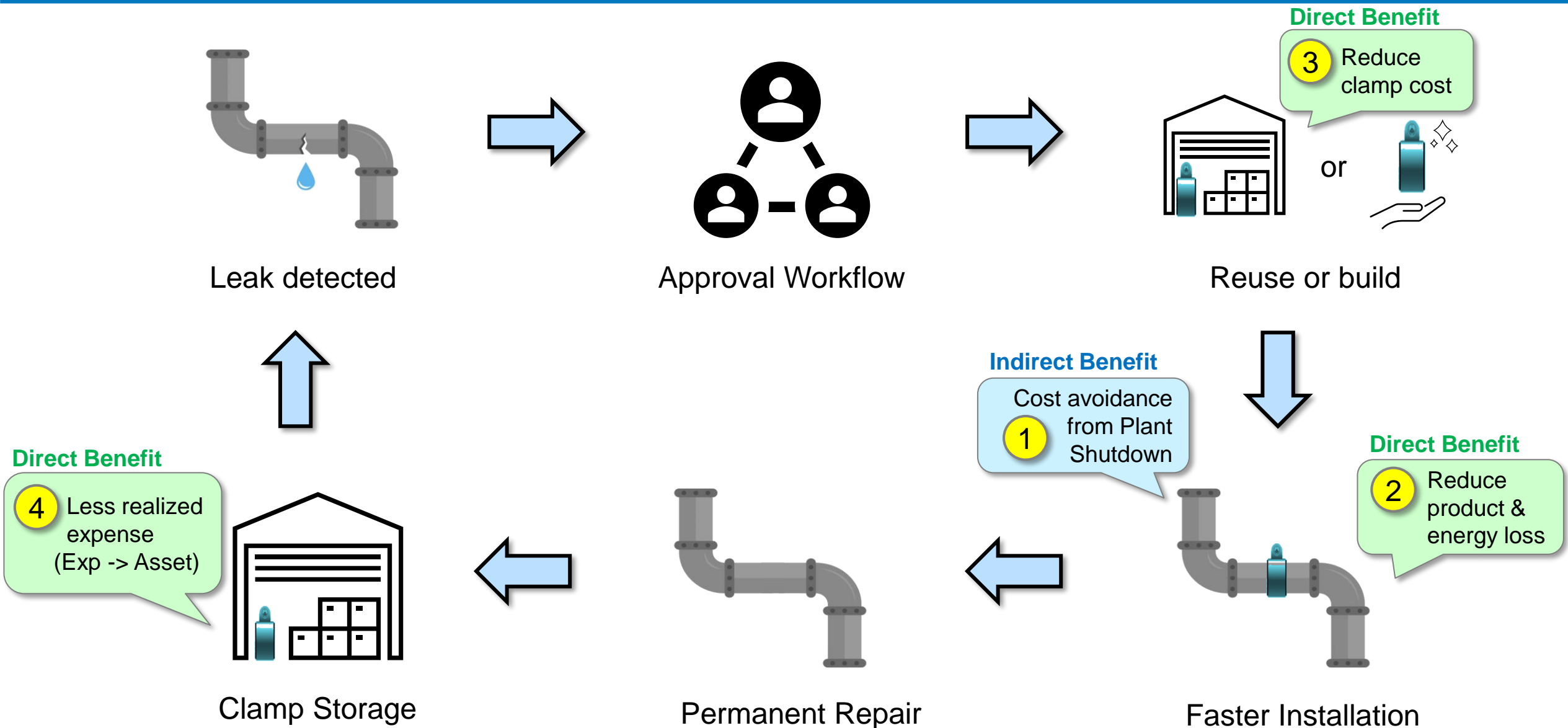
Duration (Months): 12

Phase	Description	Target date	Investment (MB)
1	Continue eTCM program improvement as prototype approved in 2020 Shark Tank	Nov 2021	2.0
2	eTCM Go-live to all BU in GC	Dec 2021	0.5
Total			2.5

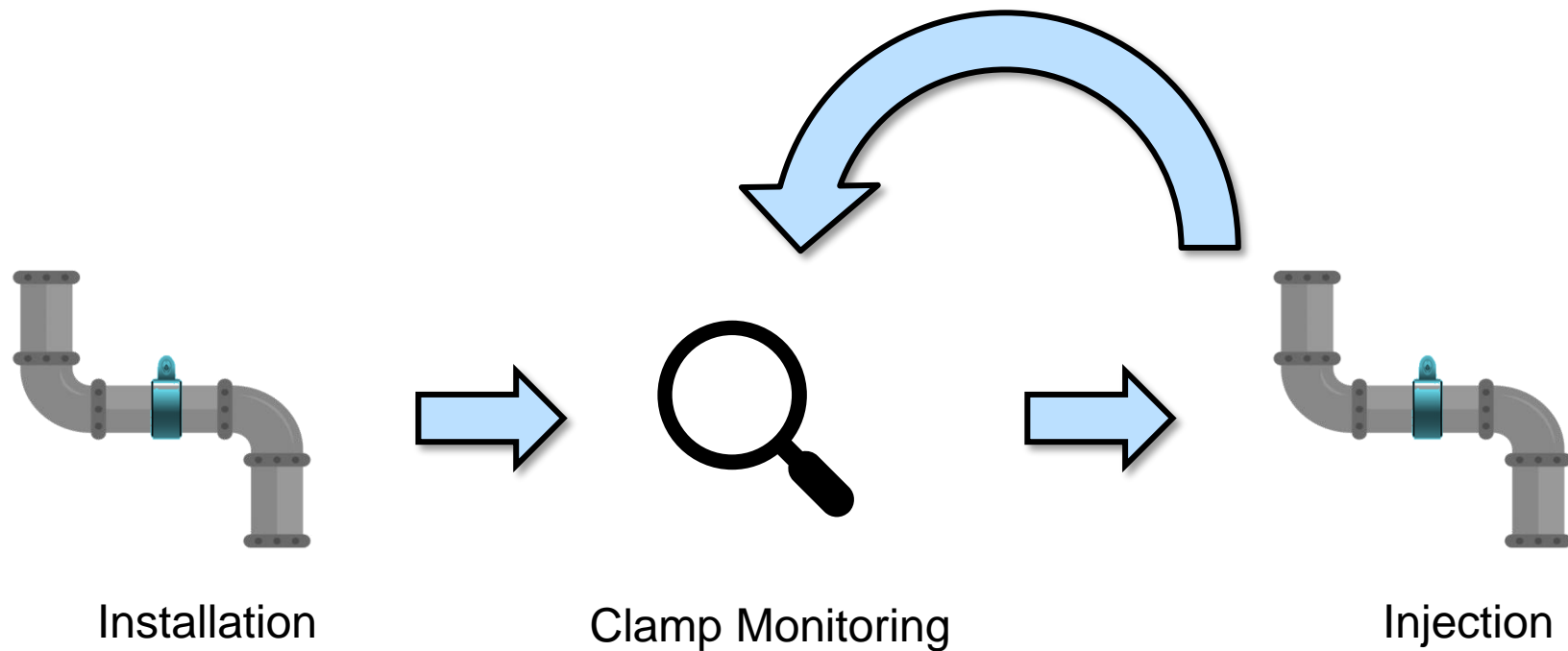
As-Is Temporary Clamp Life Cycle



To-Be Temporary Clamp Life Cycle



To-Be Temporary Clamp Life Cycle



COST & BENEFIT

Business Impact



Cost saving

\$ ~0.5M/Shutdown (ARO)

\$ ~10M/Shutdown (GC)



Efficiency

50% reduction in department
processing times



Safety & Reliability

Improved safety performance
(faster processing)



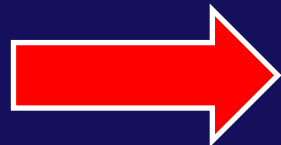
Transparency

Clear overview of all data,
processes and products.

Indirect Benefit: Cost Avoidance from Plant Shutdown

Cost of shutdown relate on plant

Unit	Consequent	S/U time	Loss	Note
U150	Total plant S/D	72h	1.07M\$	HN from 146.5 to 0 t/h, import ref from 52 to 0 t/h
U200	Total plant S/D	72h	1.07M\$	HN from 146.5 to 0 t/h, import ref from 52 to 0 t/h
U370	CX unit S/D	24h	0.031M\$	Bz to CX from 22 to 0 t/h
U380	U380 S/D	24h	0.047M\$	Total 60.9 t/h (PX-Plus 210 t/h at conversion 29%), to 0 t/h
U320	S/D xylene section and r/d heavy platformate (reduce PLF to 120 t/h and no import ref.	72h	0.28 M\$	HN from 146.5 to 120 t/h, import ref from 52 to 0 t/h
U390	R/D off spec HA	24h	0.071 M\$	C9A from 27 t/h to 0 t/h



Avg. 0.5 M\$ at 48 hrs
Avg. 0.25 M\$ (7.5 MB) at 24 hrs

Direct Cost

Investment 3.5 - 4 MB

Payback < 1 year



Product & Energy loss

~ 150,000 THB/day



Productivity +50%

14 days to 6 days



50 clamps/ plant

1000 clamps/ GC Group

(Avg. 250 clamps per year)

Direct Cost(Product)

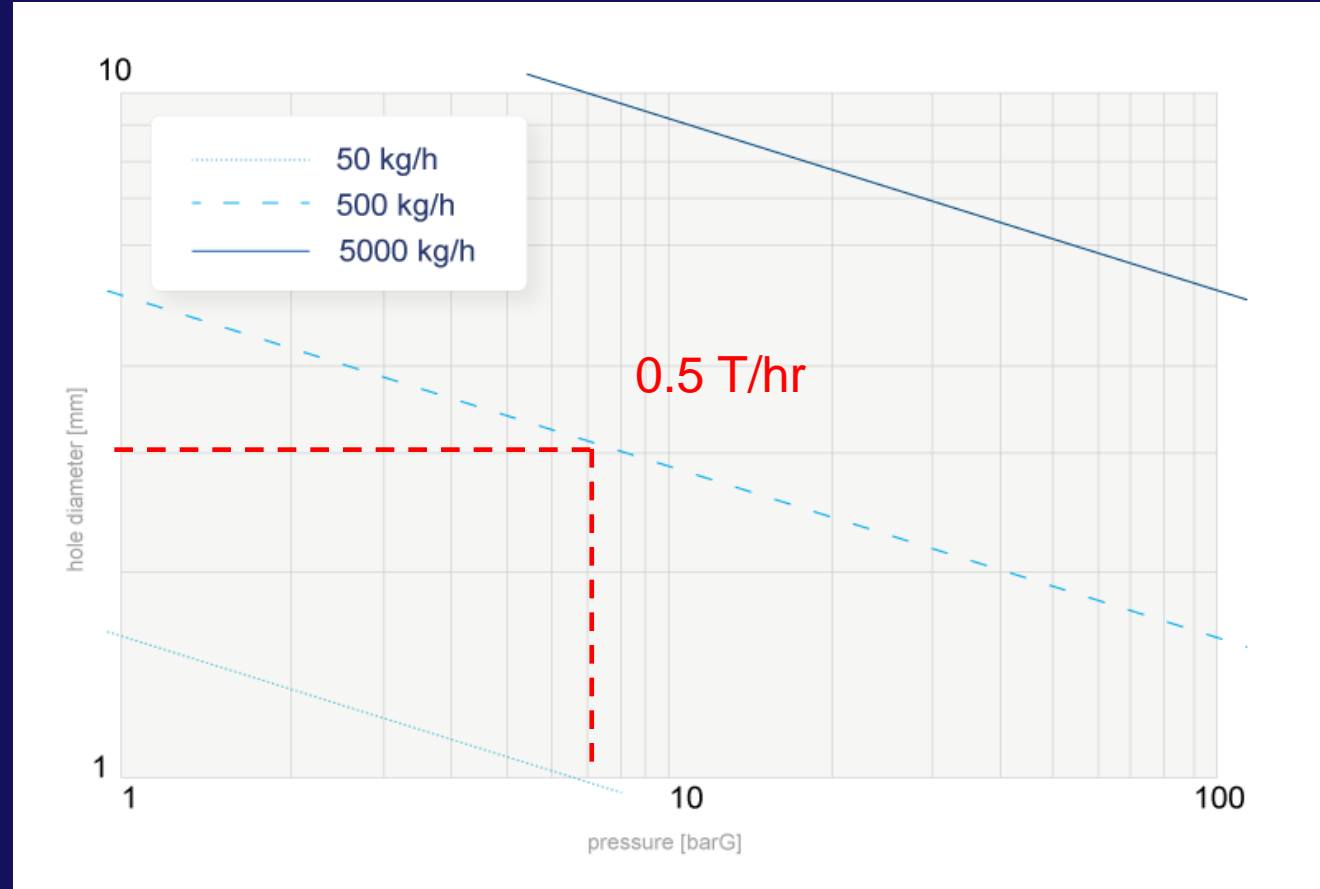


Fig. Release rate as a function of pressure and hole diameter
for a liquid with density of 650 kg/m³

Direct Cost (Product)

1. Hole size 3 mm at Pressure 7 Barg release rate at	0.5	T/hr
2. Naphtha* price is	370	US/T
3. Then 24 hr leak, calculated (0.5x370x24)	4,440	US/ Day
4. Convert to Baht (30.02 Baht/US)	133,289	Baht/Day
From historic of PTTGC, the number of HC clamps are	250	Clamps/yr
- Saving 250x133,289 =	33.32	MB/year
- Safety factor 50%	<u>16.66</u>	<u>MB/year</u>

Note*:

- Paraxylene 546 US/T

- Steam 785 Baht/T

- Polyethylene 928 US/T

- MEG 584 US/T

Direct Cost (Product)

Saving	16.66	MB/day
--------	-------	--------

If we save,

1 Day	16.66	MB
-------	-------	----

2 Days	33.32	MB
--------	-------	----

3 Days	49.98	MB
--------	-------	----

4 Days	66.64	MB
--------	-------	----

5 Days	83.30	MB
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Indirect VS Direct

7.5 MB VS 0.13 MB

(Per Day, Per Clamp)

(Another direct, If Reuse clamp will save avg. 0.075 MB per clamp)

MVP Result

Day	e-TCM					e-TCM		e-TCM
	CM431002 leak	6"-CM431003 leak	SL940003	CM940005-1	CM940005-2	2021-003-A-P1/Unit 250	2021-002-A-P1/Unit 100	2021-003-A-P1/Unit 100
Create	-	-	-	-	-	-	-	-
Inspection review	4.349	0.948	0.006	0.014	0.000	0.002	0.003	0.442
plant maintenance review	8.924	1.331	8.061	4.857	0.795	3.867	0.001	0.010
clamp design	0.126	0.235	0.758	4.157	7.229	0.020	5.771	2.190
design approval	0.046	0.019	0.181	0.002	0.036	0.005	0.008	0.024
implement approval	0.496	0.010	0.007	0.005	0.017	0.097	0.173	0.071
Execution	6.299	6.078	4.985	6.972	7.930	0.971	2.722	5.028
Total Completed	<u>20.240</u>	<u>8.622</u>	<u>13.998</u>	<u>16.007</u>	<u>16.007</u>	<u>4.962</u>	<u>8.678</u>	<u>7.765</u>

Avg. 14.975 days

Avg. 6.22 days

MVP Result (eTCM)

TEMPORARY ON STREAM LEAK SEALING LOG (A-P1)

OP No.	Unit No.	Tag No./ Line No.	Inspection Review Time (hrs)	Plant Maintenance Review time (hrs)	Clamp Design time (hrs)	Design Approval time (hrs)	Implementation Approval time (hrs)	Execution time (hrs)	Total time (hrs)	Total time (days)
2021-003-A-P1/Unit 250	Unit 250	250-E-1	0.05	23.33	0.48	0.10	2.30	23.28	49.54	4.96
2021-001-A-P1/Unit 250	Unit 250	250-PDT-126	2.22	32.25	28.88	0.03	2.32	52.00	117.70	4.90
2021-004-A-P1/Unit 250	Unit 250	250-TE-69	2.38	0.30	0.57	0.03	2.27	23.13	28.68	1.20
2021-002-A-P1/Unit 250	Unit 250	250-PDT-122	0.12	32.77	28.48	0.05	2.90	64.00	128.32	5.35
2021-001-A-P1/Unit 100	Unit 100	100-LGR308(100-V2) Spoon Piece upper side corro	0.12	0.35	208.32	0.72	1.03	55.93	266.47	11.10
2021-002-A-P1/Unit 100	Unit 100	100-LGR355(100-V8) Spoon Piece upper& Lower s	0.07	0.03	138.50	0.18	4.13	65.33	208.24	8.68
2021-002-A-P1/Unit 940	Unit 940	CM940001	0.05	0.38	18.58	0.58	2.77	116.55	138.91	5.79
2021-003-A-P1/Unit 100	Unit 100	100-LT55 (100-V8)Spoon Piece upper& Lower side	10.62	0.22	13.00	0.55	1.68	120.67	146.74	7.77




Avg. 6.22 days

Saving = (14.975-6.22)*0.13 = 1.13 MB/clamp

If Steam leak = (14.975-6.22)*9420 = 82,472.1 B/clamp

Secret

Benefit Calculation: Clamp Cost Reduction

Clamp Cost Reduction	=	Average Clamp Cost	x	New Clamp Per Year	x	%Reused Clamp
						
	=	75k THB/Clamp		250 Clamps/Year		10%
	=	1.88 MB/year				

- Remarks**
- 1. %Reused Clamp is initially assumed at 10% meaning that after implementation, 10% of leakage can immediately reuse existing clamp. This percentage should continue to grow as we have more clamp on hand.

Benefit Calculation: Less Realized Expense

As-Is (OPEX)		
Dr.	New Clamp Expense	75k
Cr.	Vendor	75k

To-Be (Fixed Asset)		
Acquisition		
Dr.	New Clamp Asset	75k
Cr.	Vendor	75k
Depreciation - Monthly		
Dr.	Clamp Depreciation Expense	15k
Cr.	Accumulated Depreciation	15k

Clamp Expense

=

Original Clamp Expense

-

New Clamp Dep. Expense

x

New Clamp Per Year

x

(100% - %Reused Clamp)

=

75k THB/Clamp

15k THB/Clamp

250 Clamps/Year

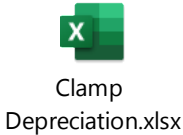
(100% - 10%)

=

13.5 MB/year

Remarks

- 1. Clamp useful life assumed at 4 years, scrap value 1 THB.
- 2. Depreciation method assumed to be Straight line total useful life - daily



INITIAL STUDY (RESEARCH / HACKATHON)



SHARK TANK
SEASON 3



Temporary Clamp Management (TCM)

Secret

The background image shows an industrial facility, possibly a refinery or chemical plant, with a large fire or explosion occurring on the left side. The fire is bright orange and yellow, with thick smoke rising from it. The facility features a complex network of pipes, valves, and structural steel. The overall scene is dark and dramatic, emphasizing the severity of the incident.

Problem while leakage

Productivity

Safe & Health

Cost

Environmental

Current Process

TEMPORARY ON STREAM LEAK SEALING LOG (GC4)											
OP No.	Tag No.	Date	Unit No.	Equipment No., Line No., Class	Repair Location	Temporary Repair Completion Date	Method	Repair Method	Contractor	Inspector	MOC No.
980432	1	3/5/2018	100	100-ME1 body Isolated (37°-480/0001-ME-13-00)	100-ME1 body Isolated	3/5/2018	Steam	Visual Check	CR	Thompson T	A-P1-2018061
980432	2	6/1/2019	432	432-801 steam pilot valve Isolated	Temporary leak sealing on valve (372-801/01)	7/6/2019	IRC	Visual Check & Check Gas	CR	Palakorn S.	A-P1-2019050
980431	3	6/25/2019	431	2°-PL431009-A2A1-B1	Temporary leak sealing on double pipe (date later side of 431-E1)	6/26/2019	IRC	Visual Check & Check Gas	CR	Palakorn S.	A-P1-2019049
980290	4	6/21/2019	250	250-B1	Temporary leak sealing on leak flange	6/24/2019	Steam	Visual Check	CR	Thompson T	A-P1-2018043

Change new gasket complete 23/06/63											
Tag No.	Unit No.	Equipment No., Line No., Class	Repair Location	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18
980432	432	432-ME1	2° Line pilot gas 432/001	No leak	No leak	No leak	No leak	No leak	No leak	No leak	No leak
980431	431	2° Line pilot gas 431/001	No leak	No leak	No leak	No leak	No leak	No leak	No leak	No leak	No leak



MM

Meata M <A-P1/2026>

To Palakorn Sat <T-II-IP2/2201>

Cc Manoch P <A-MN-A1/2422>; Arruk B <A-MN-A1/2407>; Aekarat S <A-MN-A1/2219>; Worapan M <A-MN-MP/3016>; Tikumpon T <T-II-IP2/2292>; Napaphat T <T-II-IP2/2292>;

Signed By There are problems with the signature. Click the signature button for details.

Approve as propose krub.

Client : PTT Global Chemical Co., Ltd. (Branch 4)

Contact Person : Ratum Worapan Meboon

Tag/Unit No. : 940-V7

Leak Description : 2"X45" Elbow

Design Temperature : 230 Dgr (°C)

Design Pressure : 5 Kg/Cm²g

Project : Q20F0083

Quoted Value : THB 45,994

Urgency : HIGH

DESIGN

Palakorn Sat <T-II-IP2/2201>

To Prompong Promsen; Worapan M <A-MN-MP/3016>

Cc Manoch P <A-MN-A1/2422>; Arruk B <A-MN-A1/2407>; Aekarat S <A-MN-A1/2219>; Michael Velders; Wutthiwat Dinprang; Sorawat Dinprang; Napaphat Tangwanittichakorn

You forwarded this message on 6/23/2020 9:16 AM.

Dear all;

Clamp design was approved krub. No need to do NDE due to steam.

Best regard;

Palakorn Sat.

2201

Current Issues



Disconnected

Many platforms that do not interconnect so the data cannot be easily maintained and shared



Manual Process

As there is no single point of stock relation, it's easy to lose stock and misplace their location

Current issues



Time Consuming

Many platforms that do not interconnect so the data cannot be easily maintained and shared



Data Integrity

The accuracy and consistency of data over its entire life-cycle



Resources

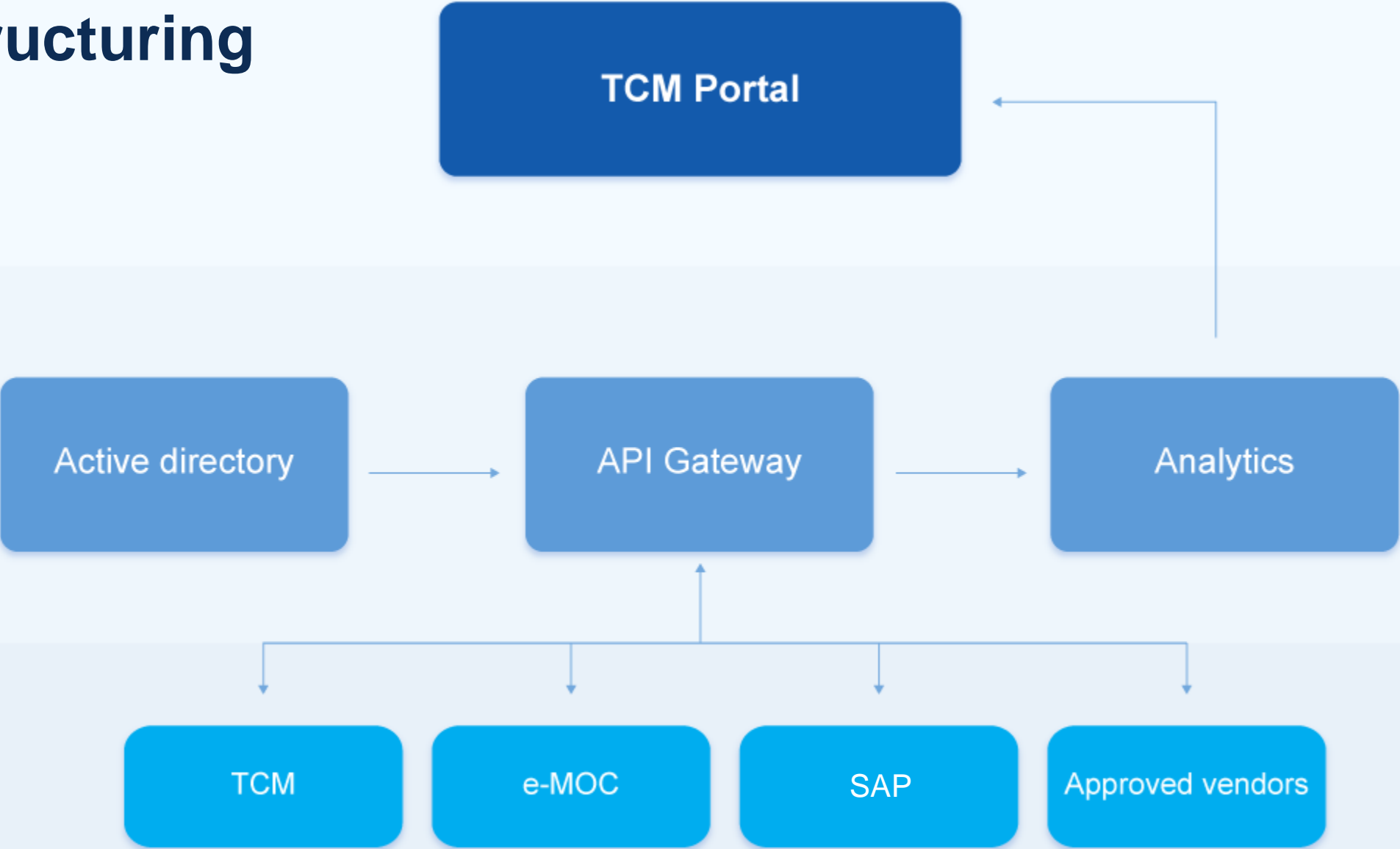
As there is no single point of stock relation, it's easy to lose stock and misplace their location

IMPLEMENTATION SCOPE & APPROACH

Temporary Clamp Management

A simplified portal allows all staff and third parties to log into one single platform

Restructuring



Daily working platform

App layer (Automated)

Existing systems

Assisted Reporting

Making report creation and management easier

Plant information

Location

Branch 5 (GC5): Aromatics 2 Plant

Plant VP

Pratit Sirivarin

Unit

275

Leak details

Fluid type

Hydrocarbon (C6 - C9)

Fluid description

MP Cond


Equipment/Piping tag no.

2" CM940005-MS-11

Repair location detail

Line MP Steam condensate above 500-AT-227 steam elbow leak

Leaking picture



GC

Online leak sealing request

CREATE REQUEST

4

Draft reports

6

Waiting for design approval

3

Waiting for VP approval

2

Waiting for installation

Search

Plant

Unit

All reports

Draft reports

Waiting for design approval

Waiting for VP approval

Waiting installation

Report No.	Plant	Unit	Fluid type	Risk	Status
<input type="checkbox"/> A-P1-2020/128	GC6	250	Hydrocarbon (C6 - C9)	Very Low	Draft
<input type="checkbox"/> A-P1-2020/128	GC10	432	Hydrocarbon (> C9)	Very Low	Draft
<input type="checkbox"/> A-P1-2020/128	GC13	910	Hydrocarbon (> C9)	Medium	Draft
<input type="checkbox"/> A-P1-2020/128	GC5	325	Hydrogen (H2)	Low	Draft
<input type="checkbox"/> A-P1-2020/128	GC11	275	Hydrocarbon (C6 - C9)	Low	Design approval
<input type="checkbox"/> A-P1-2020/128	GC9	431	Other Utilities (N2, Air)	High	VP approval
<input type="checkbox"/> A-P1-2020/128	GC2	850	Steam	High	Design approval
<input type="checkbox"/> A-P1-2020/128	GC7	250	Chemical	Extreme	Design approval
<input type="checkbox"/> A-P1-2020/128	GC8	431	Other Utilities (N2, Air)	Extreme	Design approval

Risk assessment

Severity

High

Consequence

Environment

Likelihood

Likely

Risk level

3

Request updated

Vendor has submitted the quotation please review and response as soon as possible.

Monitoring

Creation of automated flows and smart suggestions

The screenshot displays the TCM Monitoring web application. The interface includes a sidebar with navigation links: Dashboard, Map, Online leak sealing request, and Monitoring Schedule. The main content area is titled "TCM Monitoring" and features a search bar and tabs for "All reports", "Upcoming", and "Overdue". A table lists monitoring reports with columns for Report No., Method, Frequency, Last inspection result, Next inspection, and Status. A "Permanent repair schedule" modal is open, showing a date picker set to 21/02/2021. A "Monitoring Record" modal is also open, displaying a table with columns for Condition, Attachment, and Due on. The table lists two records: one with condition "Good" and attachment "img_2020912_0812" due on 12/08/2021, and another with condition "Leak" and attachment "img_2014512_2147" due on 05/10/2020.

Report No.	Method	Frequency	Last inspection result	Next inspection	Status
<input type="checkbox"/> A-P1-2020/128	VOC check	Bi-weekly	Good condition	14/05/2021	On plan
<input type="checkbox"/> A-P1-2020/128	VOC check	Bi-weekly	Good condition	14/05/2021	On plan
<input type="checkbox"/> A-P1-2020/128	VOC check	Bi-weekly	Good condition	14/05/2021	Overdue
<input type="checkbox"/> A-P1-2020/128	VOC check	Bi-weekly	Good condition	14/05/2021	On plan
<input type="checkbox"/> A-P1-2020/128	VOC check	Bi-weekly	Good condition	14/05/2021	On plan
<input type="checkbox"/> A-P1-2020/128	VOC check	Bi-weekly	Good condition	14/05/2021	On plan
<input type="checkbox"/> A-P1-2020/128	VOC check	Bi-weekly	Good condition	14/05/2021	On plan
<input type="checkbox"/> A-P1-2020/128	VOC check	Bi-weekly	Good condition	14/05/2021	On plan
<input type="checkbox"/> A-P1-2020/128	VOC check	Bi-weekly	Good condition	14/05/2021	On plan
<input type="checkbox"/> A-P1-2020/128	VOC check	Bi-weekly	Good condition	14/05/2021	On plan

Permanent repair schedule

Date: 21/02/2021

Monitoring Record

Condition	Attachment	Due on
<input type="checkbox"/> Condition	<input type="text" value="Attachment"/>	<input type="text" value="DD/MM/YYYY"/>
<input type="checkbox"/> Good	<input type="text" value="img_2020912_0812"/>	<input type="text" value="12/08/2021"/>
<input type="checkbox"/> Leak	<input type="text" value="img_2014512_2147"/>	<input type="text" value="05/10/2020"/>

Interactive Map


Visual overview of all repairs

The screenshot displays the 'Interactive Map' interface for a refinery. The main area shows an aerial view of the facility with four numbered markers (1, 2, 3, 4) indicating specific repair locations. The interface includes a sidebar menu on the left with the following items: Dashboard, Map (selected), Online leak sealing request, Monitoring Schedule, Permanent repairs, and Clamp inventory. The top navigation bar shows the GC logo and a dropdown menu for 'Branch 6 (GC6): Refinery'. The right-hand panel lists four repair items:

Repair ID	Valve ID	Serial Number	Status
A-P1-2020/128	Valve - 458-H3#10	083/5469	WAITING FOR INSTALLATION
A-P1-2020/131	Valve - 469-169#06	065/1469	WAITING FOR VP APPROVAL
A-P2-2020/145	Valve - 432-L5#12	085/2498	WAITING FOR INSTALLATION
A-Q1-2020/152	Valve - 447-H2#04	082/3153	WAITING FOR DESIGN APPROVAL

Inventory Management

Real time data tracking



Dashboard

Map

Clamp information

Part no.

Clamp type

Design temperature °C

Design pressure barG

Material type

Clamp picture

Select image to upload

Clamp specification

Select file to upload

Select file F-(TP-PM)-(TP-PM)-002-01...

Clamp inventory

Search

Part No.	Clamp Type	Design Temperature	Design Pressure	Size	Material Type
125694	Clamp type	29 °C	40 barG	Normal	Stainless steel
126985	Clamp type	25 °C	45 barG	Normal	Carbon steel
326985	Clamp type	34 °C	28 barG	Normal	Carbon steel
124597	Clamp type	30 °C	47 barG	Normal	Carbon steel
326985	Clamp type	29 °C	45 barG	Normal	Stainless steel
127469	Clamp type	34 °C	32 barG	Normal	Stainless steel
459325	Clamp type	32 °C	33 barG	Normal	Carbon steel
123546	Clamp type	27 °C	39 barG	Normal	Carbon steel
126985	Clamp type	27 °C	33 barG	Normal	Carbon steel
125896	Clamp type	35 °C	47 barG	Normal	Stainless steel
459325	Clamp type	22 °C	39 barG	Normal	Stainless steel
124597	Clamp type	25 °C	47 barG	Normal	Stainless steel
125694	Clamp type	29 °C	32 barG	Normal	Stainless steel
125896	Clamp type	34 °C	40 barG	Normal	Stainless steel

Scope of change

Detail

Stop leak by clamping

Permanent repair schedule

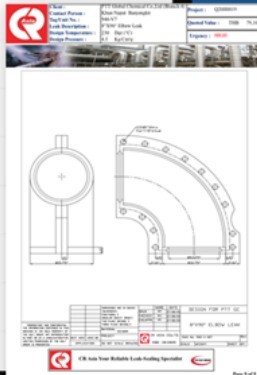
Date

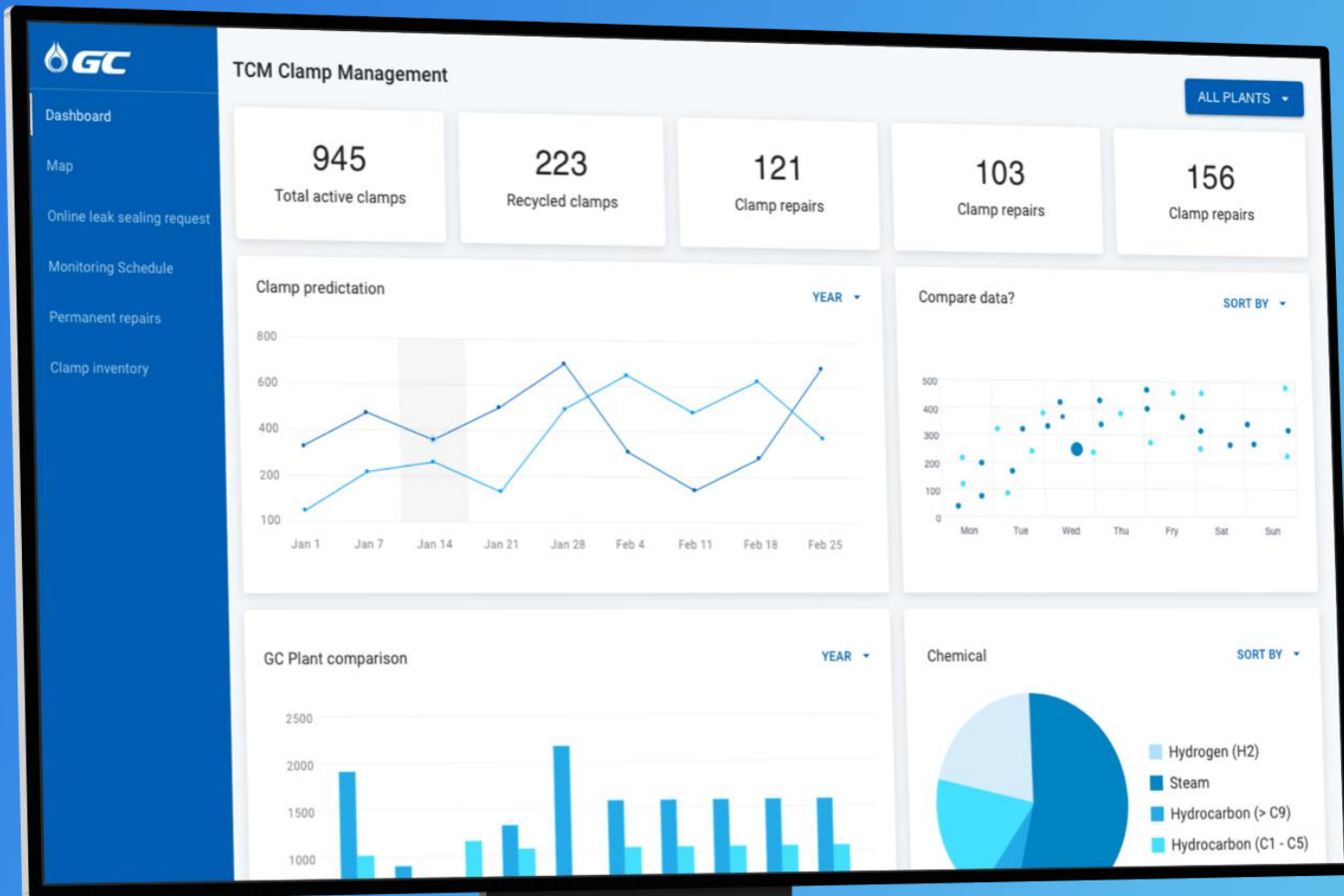
21/02/2021

Design specification

PDF

F-(TP-PM)-(TP-PM)-002-01...





Dashboard

Tracking and analytical
reporting made easier

Value Proposition

One single platform

We can create a single portal and bring relevant information into one location from existing systems creating a single reliable platform

Low maintenance

Single platform would allow for focused updates and reduced costs for further feature scaling in the future and reduce complications



Tracking made easy

As each step is broken down, relative and logical tracking of repairs, events and schedules assist users in order to keep track of ongoing progress

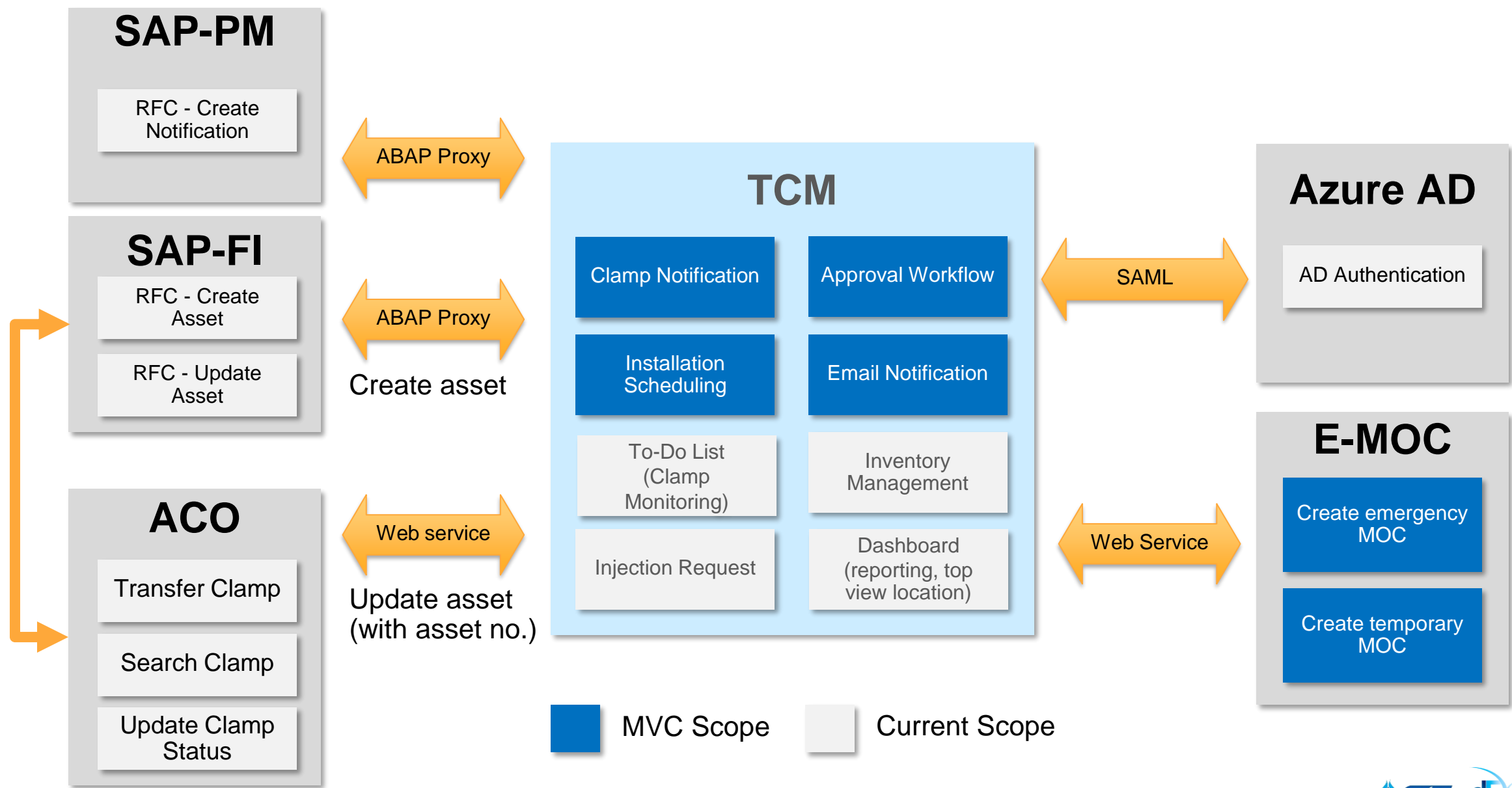
Breakdown processes

One primary flow with various departments being provided tasks needed for completion only when relevant

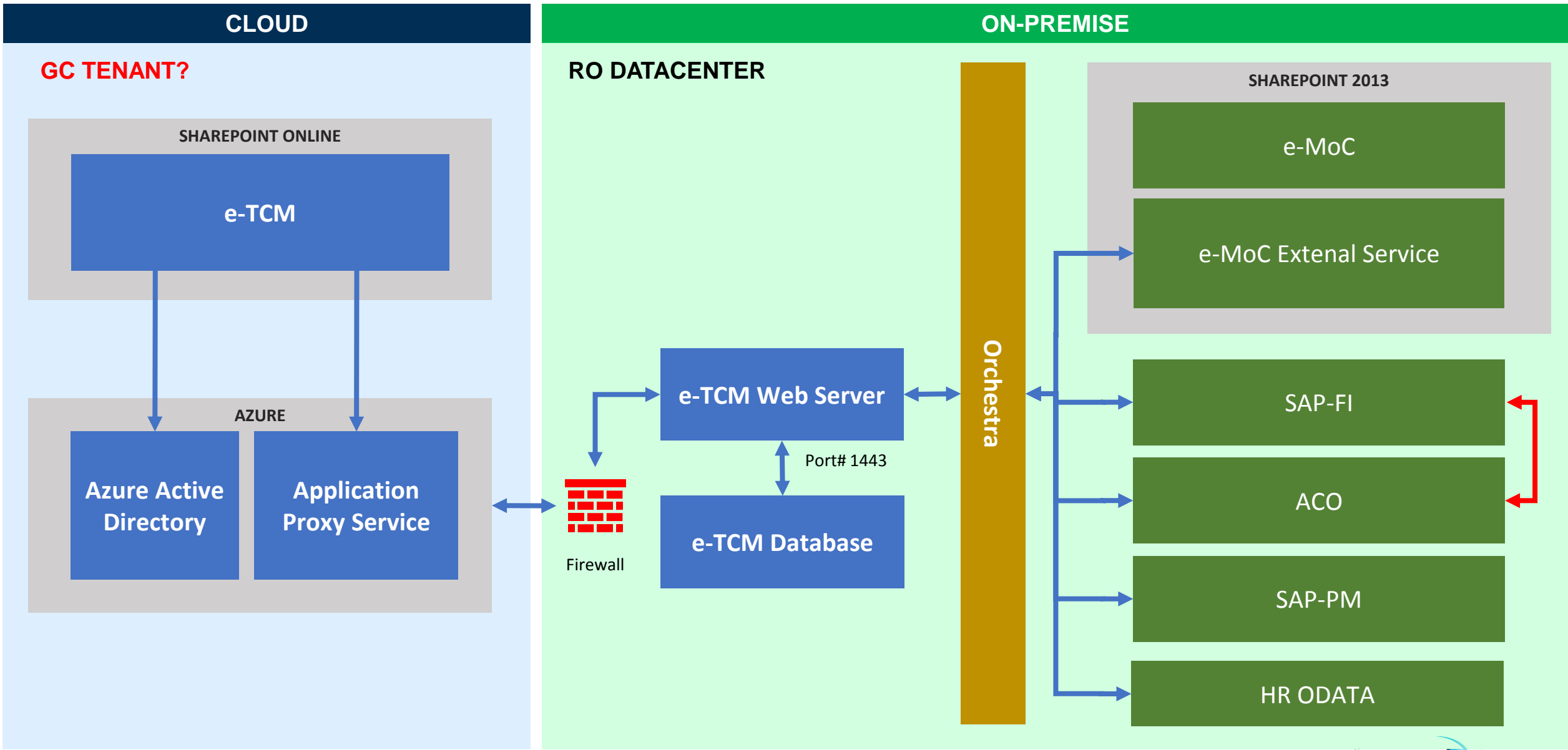
Zero Leak

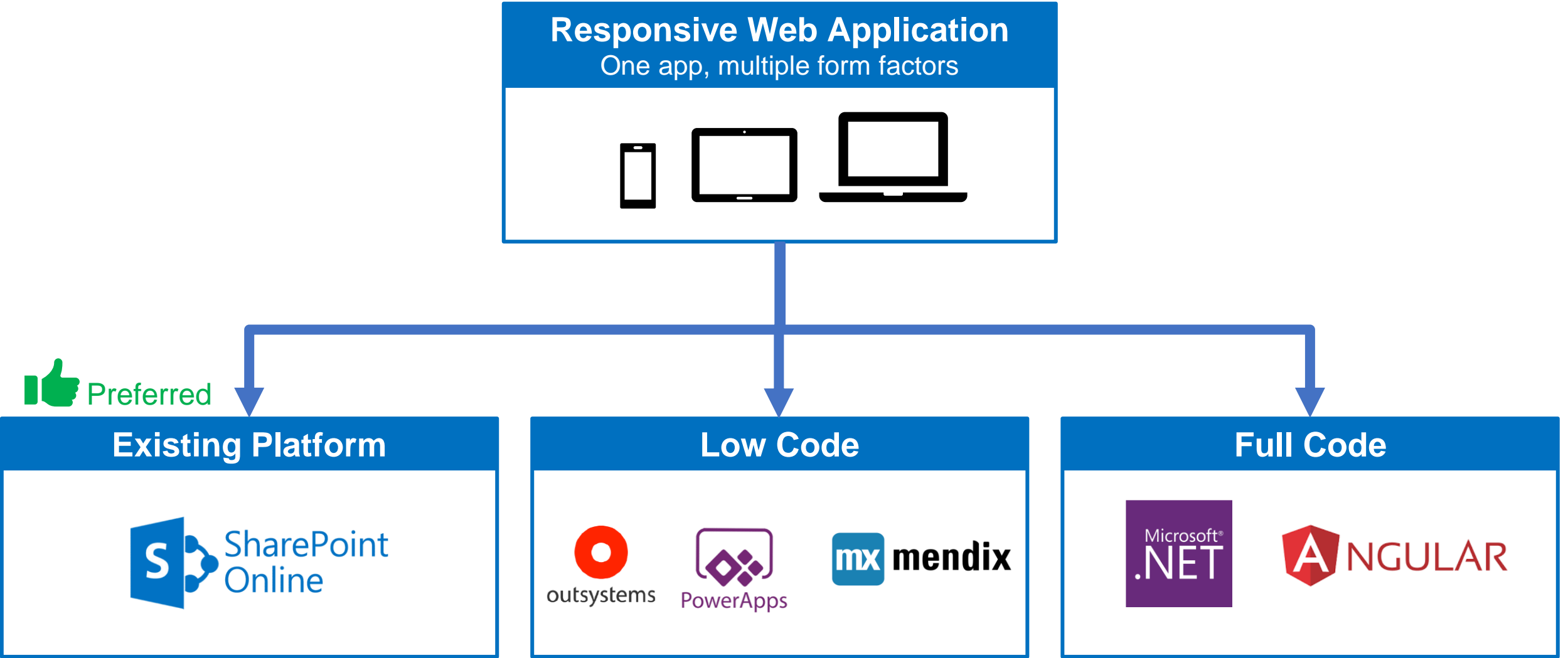
The foundation for future platforms leading the vision of digital transformation in the organisation. Utilising machine learning and big data analysis to accurately predict potential risk and loss of productivity.

Business Architecture



System Architecture





Technology Comparison

	PROs	CONs
Traditional Development	<ul style="list-style-type: none">- Custom made to fit our needs- Good for complex requirement	<ul style="list-style-type: none">- Time consuming development- Potentially more expensive
Low Code Platform	<ul style="list-style-type: none">- Fast delivery of new software- Agility to respond to change/update- Multi-experience Made Easy	<ul style="list-style-type: none">- Lack of customization- Get tied to low code platform

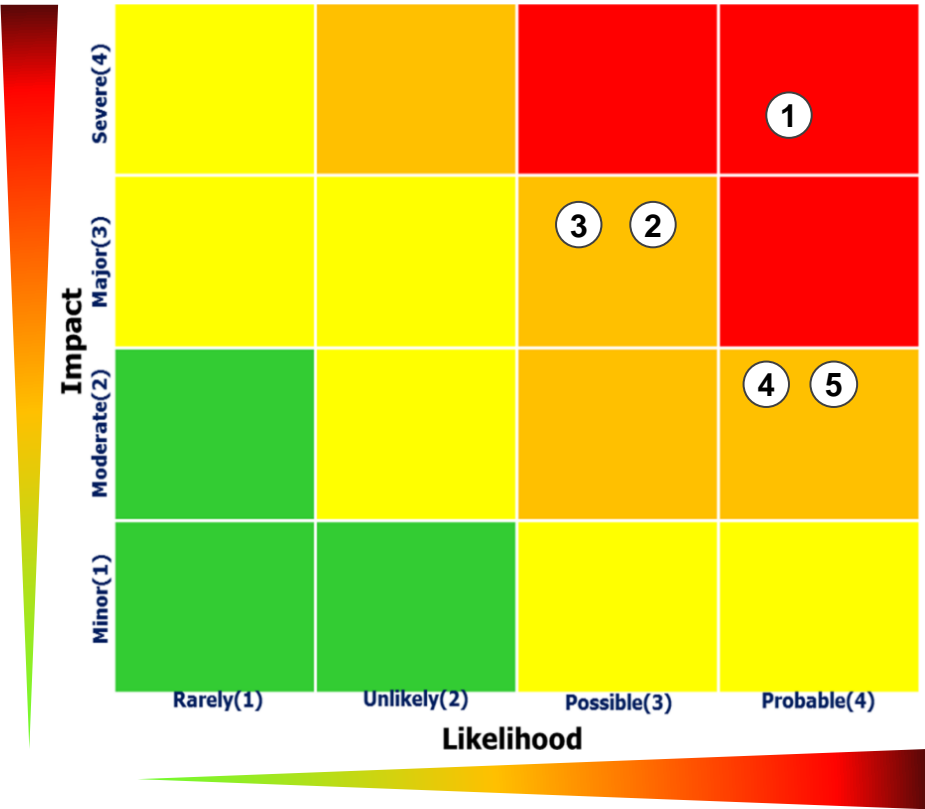
Development & Execution Plan



RISK ASSESSMENT

Project Risks

Risks assessment



Risks Management Plan (High and Medium Risks)

No.	Risk Category & Description	Impact	Likeli hood	Mitigation	PTA	Status
1	Resource					
2	Schedule					
3	Scope/Requirement					
4	Technology/Technical					
5	Finance					
6	Legal/Regulation					
7	Quality					
8	Vendor/Supplier					
9	User					
10	Safety/Environment					
11	Process/Operation					

Guideline provided in Appendix B.

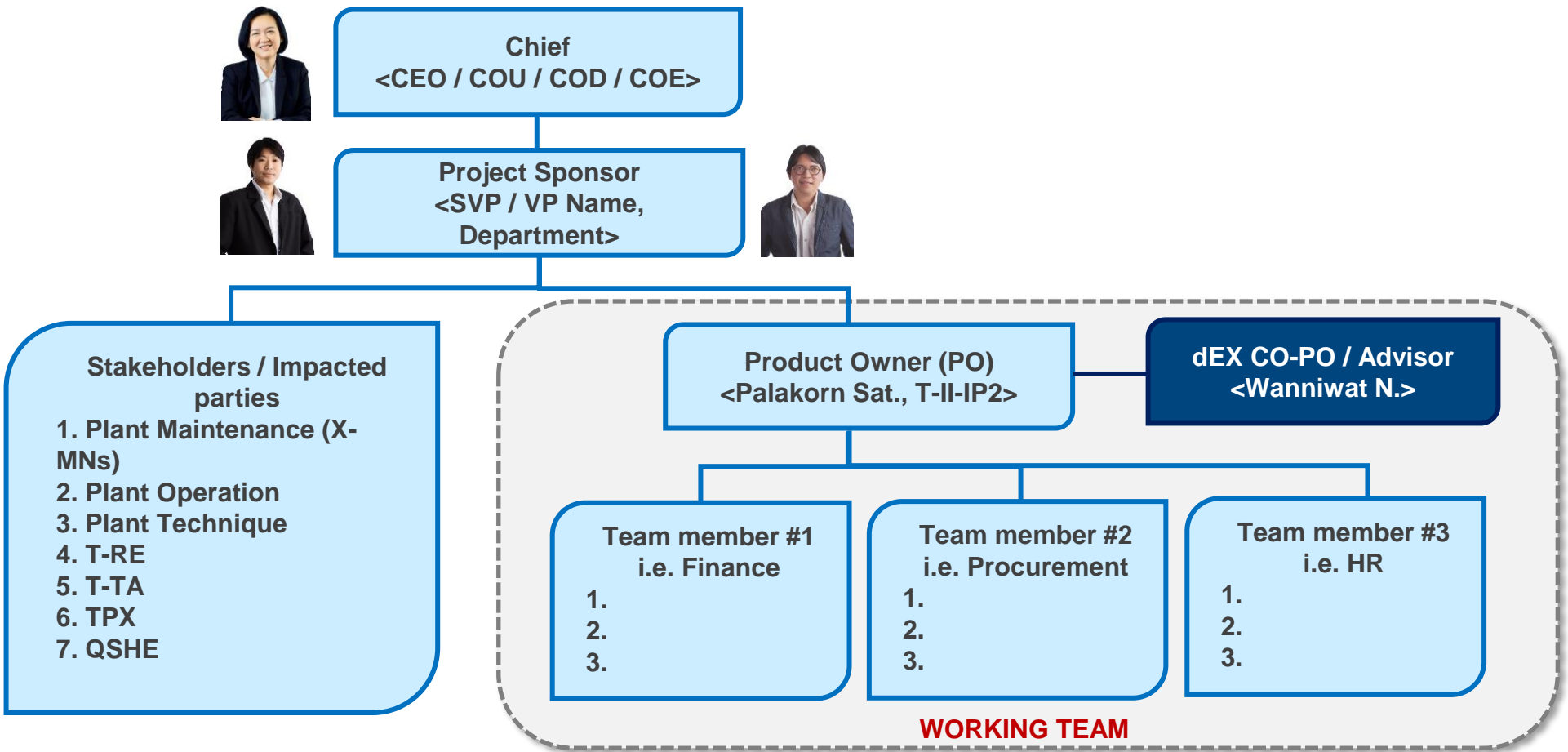
VENDOR SURVEY & COMPARISON

Vendor Sourcing



TEAM ORGANIZATION

Team Organization



Our Team



Project Coordination
Engineer

Inspection
Engineer

Project
Coordinator

Sr. Corrosion
Engineer

Inspection
Engineer

THANK YOU



Backup Slides

Cost of shutdown relate on plant

Unit	Consequent	S/U time	Loss	Note
U150	Total plant S/D	72h	1.07M\$	HN from 146.5 to 0 t/h, import ref from 52 to 0 t/h
U200	Total plant S/D	72h	1.07M\$	HN from 146.5 to 0 t/h, import ref from 52 to 0 t/h
U370	CX unit S/D	24h	0.031M\$	Bz to CX from 22 to 0 t/h
U380	U380 S/D	24h	0.047M\$	Total 60.9 t/h (PX-Plus 210 t/h at conversion 29%), to 0 t/h
U320	S/D xylene section and r/d heavy platformate (reduce PLF to 120 t/h and no import ref.	72h	0.28 M\$	HN from 146.5 to 120 t/h, import ref from 52 to 0 t/h
U390	R/D off spec HA	24h	0.071 M\$	C9A from 27 t/h to 0 t/h

Average 0.5 MUSD

Date	Hour	Minute	Day	Hour	Minute	Minute	CM431002 leak	Hour	Day
8/10/2019	11	15	-	-	-	-	Create	-	-
12/10/2019	19	37	5760	480	22	6262	Inspection review	104.367	4.349
21/10/2019	17	47	12960	-120	10	12850	plant maintenance review	214.167	8.924
21/10/2019	20	49	0	180	2	182	clamp design	3.033	0.126
21/10/2019	21	55	0	60	6	66	design approval	1.100	0.046
22/10/2019	9	49	1440	-720	-6	714	implement approval	11.900	0.496
28/10/2019	17	0	8640	480	-49	9071	Execution	151.183	6.299
						29145	Completed	485.750	20.240

Date	Hour	Minute	Day	Hour	Minute	Minute	6"-CM431003 leak	Hour	Day
23/6/2020	2	5	-	-	-	-	Create	-	-
24/6/2020	0	50	1440	-120	45	1365	Inspection review	22.750	0.948
25/6/2020	8	46	1440	480	-4	1916	plant maintenance review	31.933	1.331
25/6/2020	14	25	0	360	-21	339	clamp design	5.650	0.235
25/6/2020	14	53	0	0	28	28	design approval	0.467	0.019
25/6/2020	15	8	0	60	-45	15	implement approval	0.250	0.010
1/7/2020	17	0	8640	120	-8	8752	Execution	145.867	6.078
						12415	Completed	206.917	8.622

Date	Hour	Minute	Day	Hour	Minute	Minute	SL940003	Hour	Day
29/7/2020	15	23	-	-	-	-	Create	-	-
29/7/2020	15	31	0	0	8	8	Inspection review	0.133	0.006
6/8/2020	16	59	11520	60	28	11608	plant maintenance review	193.467	8.061
7/8/2020	11	11	1440	-300	-48	1092	clamp design	18.200	0.758
7/8/2020	15	31	0	240	20	260	design approval	4.333	0.181
7/8/2020	15	41	0	0	10	10	implement approval	0.167	0.007
12/8/2020	15	20	7200	0	-21	7179	Execution	119.650	4.985
						20157	Completed	335.950	13.998

							MN920776652		
Date	Hour	Minute	Day	Hour	Minute	Minute	CM940005-1	Hour	Day
11/10/2020	13	48	-	-	-	-	Create	-	-
11/10/2020	14	8	0	60	-40	20	Inspection review	0.333	0.014
16/10/2020	10	42	7200	-240	34	6994	plant maintenance review	116.567	4.857
20/10/2020	14	28	5760	240	-14	5986	clamp design	99.767	4.157
20/10/2020	14	31	0	0	3	3	design approval	0.050	0.002
20/10/2020	14	38	0	0	7	7	implement approval	0.117	0.005
27/10/2020	13	58	10080	-60	20	10040	Execution	167.333	6.972
						23050	Completed	384.167	16.007

							MN910010134		
Date	Hour	Minute	Day	Hour	Minute	Minute	CM940005-2	Hour	Day
26/10/2020	13	48	-	-	-	-	Create	-	-
26/10/2020	13	48	0	0	0	0	Inspection review	0.000	0.000
27/10/2020	8	53	1440	-300	5	1145	plant maintenance review	19.083	0.795
3/11/2020	14	23	10080	360	-30	10410	clamp design	173.500	7.229
3/11/2020	15	15	0	60	-8	52	design approval	0.867	0.036
3/11/2020	15	39	0	0	24	24	implement approval	0.400	0.017
11/11/2020	13	58	11520	-120	19	11419	Execution	190.317	7.930
						23050	Completed	384.167	16.007

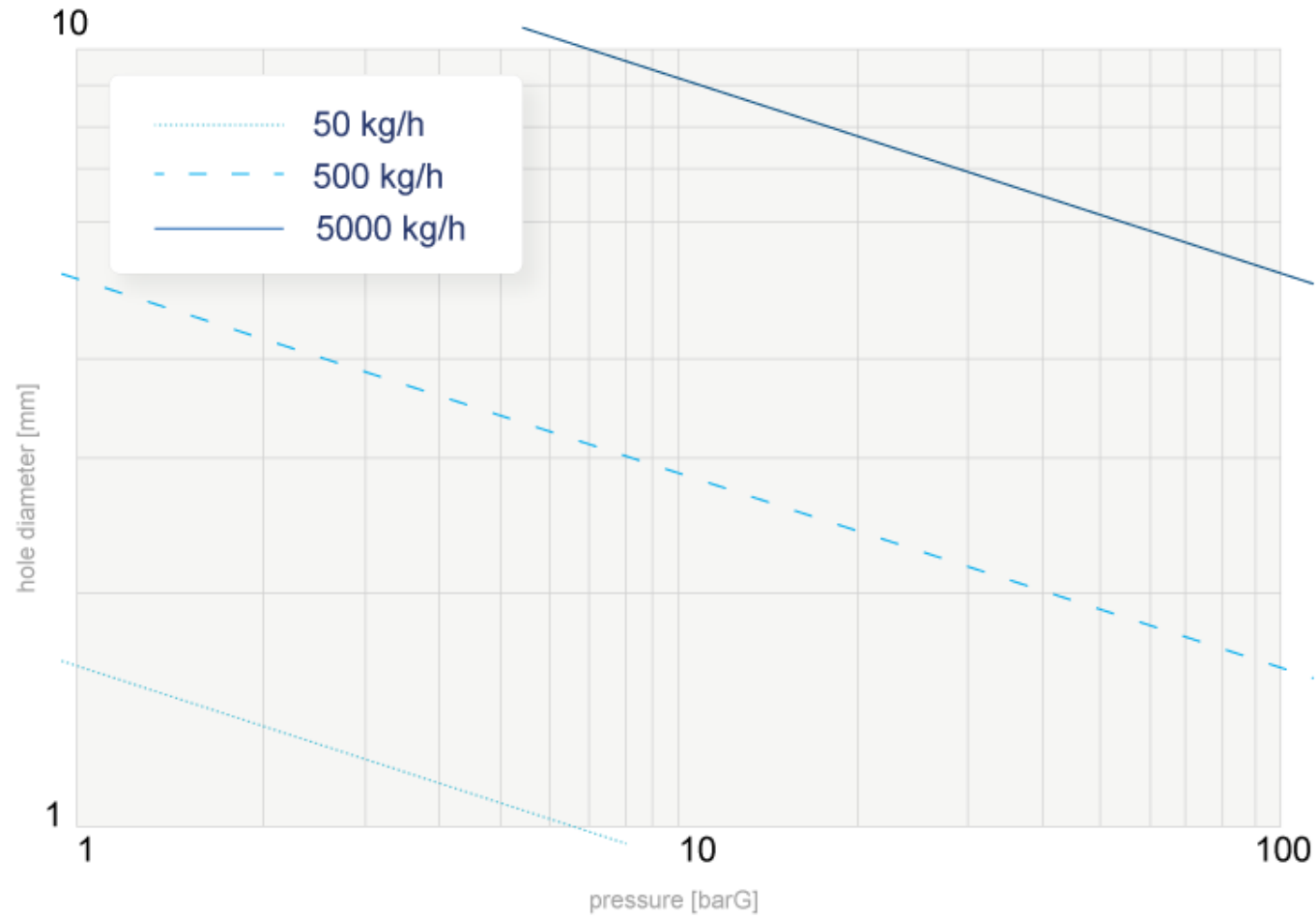


Fig. Release rate as a function of pressure and hole diameter for a liquid with density of 650 kg/m³

Table: Release Hole Sizes and Areas Used in Consequence Analyses

Release Hole Number	Release Hole Size	Range of Hole Diameters (mm)	Release Hole Diameter, d_n (mm)
1	Small	0 – 6.4	$d_1 = 6.4$
2	Medium	> 6.4 – 51	$d_2 = 25$
3	Large	> 51 – 152	$d_3 = 102$
4	Rupture	> 152	$d_4 = \min [D, 406]$

***Referred from API RP 581 Risked Based Inspection Methodology