



THE 21ST INTERNATIONAL
OPERATIONS & MAINTENANCE
CONFERENCE IN THE ARAB COUNTRIES

Digital Twins Unveiled

Simulating Asset Performance for
Optimal Management

 #OmaintecConf

An Initiative by

Organized by



EXICON.
International Group
مجموعة أكزيكون الدولية



Introduction





About me

Paul Daugalis - **B.Eng (mech) University of South Australia (1994)**
 - **Certified Maintenance and Reliability Practitioner (CMRP)**
 - **Ex-Chairman European Asset Management Committee (EAMC)**
 - **Chairman Lithuanian Technical Maintenance Engineering Association (LTPIA)**

2021 to Now AssetCoreXL – Managing Director (UAE), APM Alliance Board Member (UAE)
 2012 to 2021 Hugaas Group of Companies – CEO (UAE, Norway, Lithuania & Madagascar)
 2011 to 2012 TP Engineering - Managing Director (Lithuania)
 2006 to 2010 ARMS Reliability - Engineering Business Manager (Australia, Europe and Middle East)
 2004 to 2005 Transfield Services - Engineering Asset Services Manager across 120 different facilities (Oceania, Asia and the Middle East)
 2000 to 2003 Transfield Services - Site Manager for onshore gas production facility providing integrated maintenance and engineering services (New Zealand)
 1994 to 1999 Transfield Services - Project, maintenance and reliability engineering management for oil and gas, mining, rail, utility and facility companies (Australia)
 1992 to 1994 Exxon Mobil – Reliability Engineer (South Australia)





Case Study



Case Study

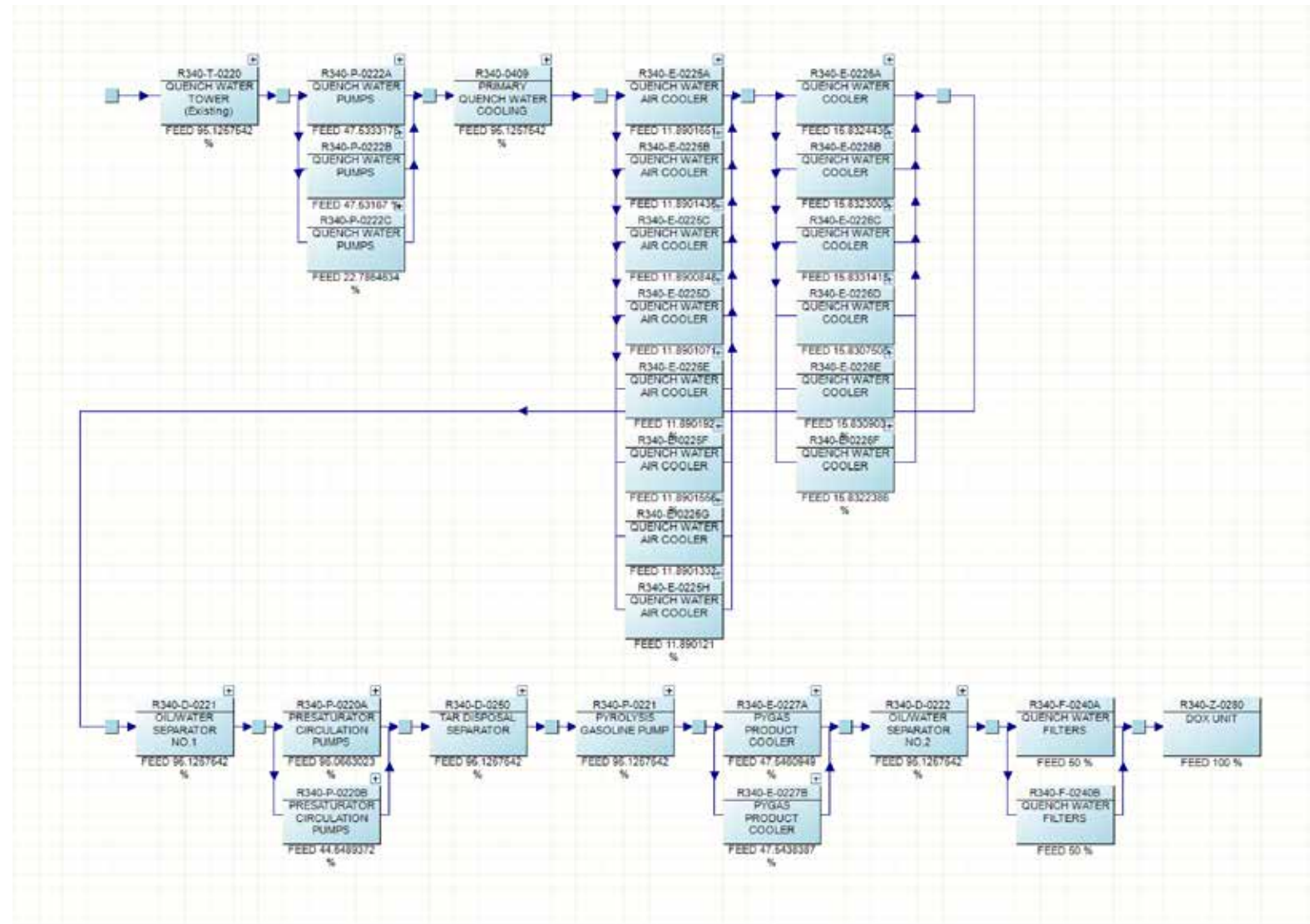
The screenshot displays a simulation software interface with a process flow diagram and a 3D rendering of an industrial plant.

Process Flow Diagram:

- Feed:** FEED 100%
- ECR01:** FURNACES & TLPS (FEED 100%)
- ECR02:** QUENCH WATER TOWER (FEED 54.9613794 %)
- ECR03:** CRACKED GAS COMPRESSION (FEED 99.00018 %)
- ECR04:** ACID GAS REMOVAL (FEED 95.047831 %)
- ECR05:** DEETHANIZER (FEED 94.9884792 %)
- ECR06:** ACETYLENE HYDROGENATION (FEED 95.0861874 %)
- ECR07:** DEETHANIZER & DEETHANIZER FEED PRE-COOLING (FEED 100%)
- ECR08:** C2 SPLITTER (FEED 94.088076 %)
- ECR09:** PROPYLENE REFRIGERATION SYSTEM (FEED 95.0487355 %)
- ECR10:** ETHYLENE REFRIGERATION SYSTEM (FEED 96.136764 %)
- ECR11:** COOLING WATER SYSTEM (FEED 94.9600021 %)
- ECR12:** STEAM DISTRIBUTION SYSTEM (FEED 96.136764 %)
- ECR13:** STEAM CONDENSATE SYSTEM (FEED 96.136764 %)

3D Rendering: A detailed 3D model of the industrial plant, showing various towers, pipes, and structures in a desert environment.

Case Study



Case Study

The screenshot displays the AuSim software interface. On the left is a 'Failure Modes' tree listing various equipment types and their failure modes. The main area shows a process flow diagram with units like ECR04 ACID GAS REMOVAL, ECR06 DEETHANIZER, ECR08 ACETYLENE HYDROGENATION, ECR07 DEETHANIZER FEED PRE-COOLING, ECR11 COOLING WATER SYSTEM, ECR12 STEAM DISTRIBUTION SYSTEM, and ECR13 STEAM CONDENSATE SYSTEM. Two configuration windows are open:

- Failure Mode Properties - CMP1.1 Compressor axial, Abnormal instrument reading:**
 - General: Failure: Maintenance
 - Distribution: Exponential
 - WebUI set: Not set
 - Distribution parameters: Mean time to failure: 64516, Standard deviation: 0
 - Non-operating failure appointment (%): 50
 - Non-operating opening appointment (%): 50
 - Start-up failure probability: 0
- Task Properties - PM102:**
 - Task enabled:
 - Interval: 70080, Offset: 0, Fixed interval:
 - Description: Overhaul compressor
 - Task ID: PM102
 - Task duration: 48, Operational cost: 1000
 - Ramp time: 4, Minimum age: 0
 - Task group: Not set
 - Resources: MECH x 4 Mechanical Fiter, M1 x 1 Compressor spare parts



Case Study

Simulation Results

Life Costs Systems Components Consequences Phases Spares Labor

ID	Description
ECR	ETHANE CRACKER UNIT
ECR02	QUENCH WATER TOWER
ECR03	CRACKED GAS COMPRESSION
ECR04	ACID GAS REMOVAL
FCR05	DEETHANIZER

ID: ECR

Total down time: 8539.67864
Std total down time: 440.69992
Error % total down time: 0.51606148
FEED Mean capacity: 94.3933305 %
FEED Std capacity: 0.257445978 %
FEED Error % capacity: 0.0272737466
Mean unavailability: 0.048742458
Unavailability at lifetime: 0.01
No of outages: 382.58
Std no of outages: 20.0614955
Error % no of outages: 0.524373868
F: 1
Time in standby: 0
*MTTO: 423.270695
*MTBO: 457.943437
*MTTR: 22.3212887

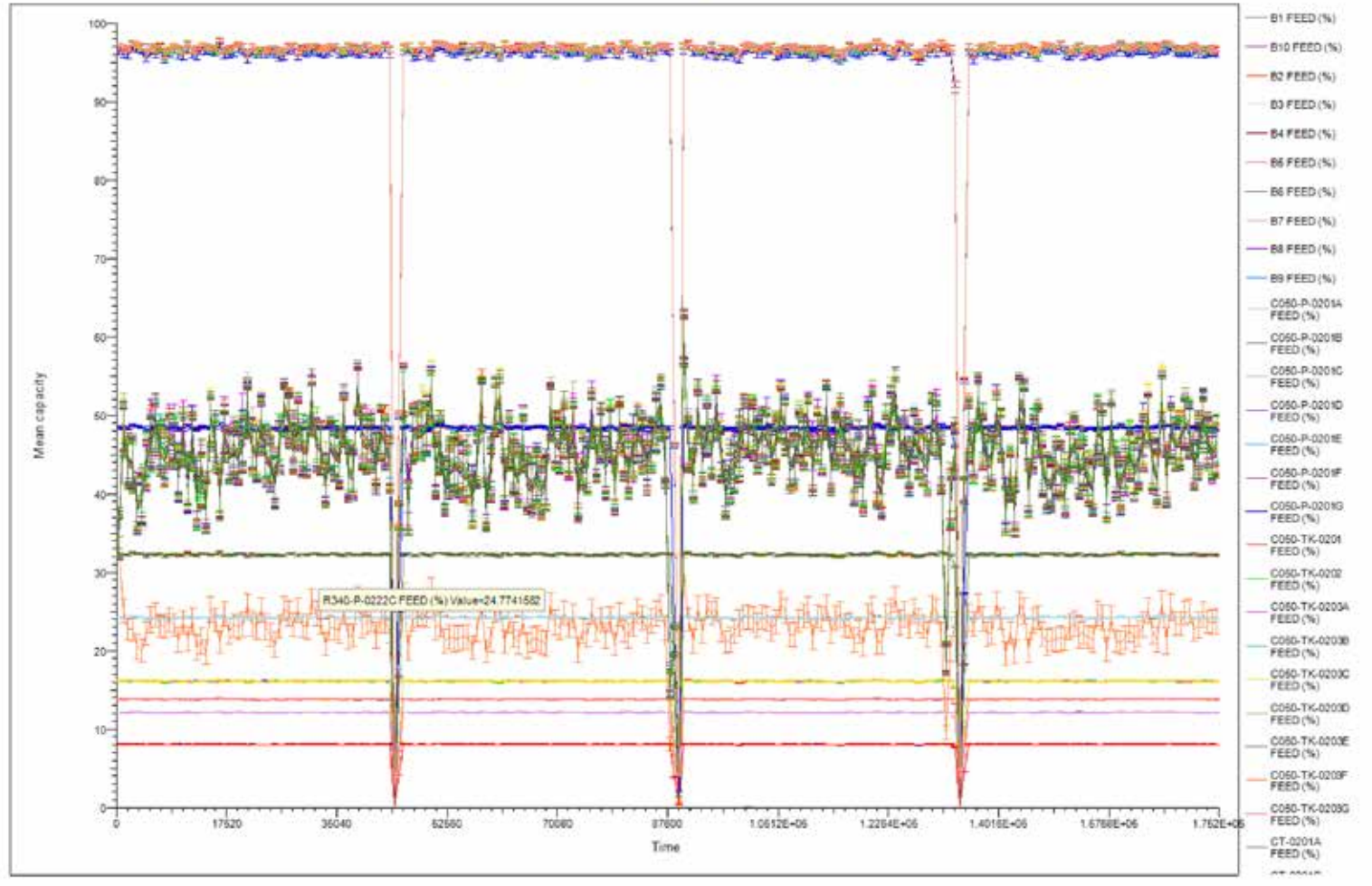
* To obtain accurate MTTO, MTBO and MTTR values set project lifetime >> MTBO

Close



Case Study

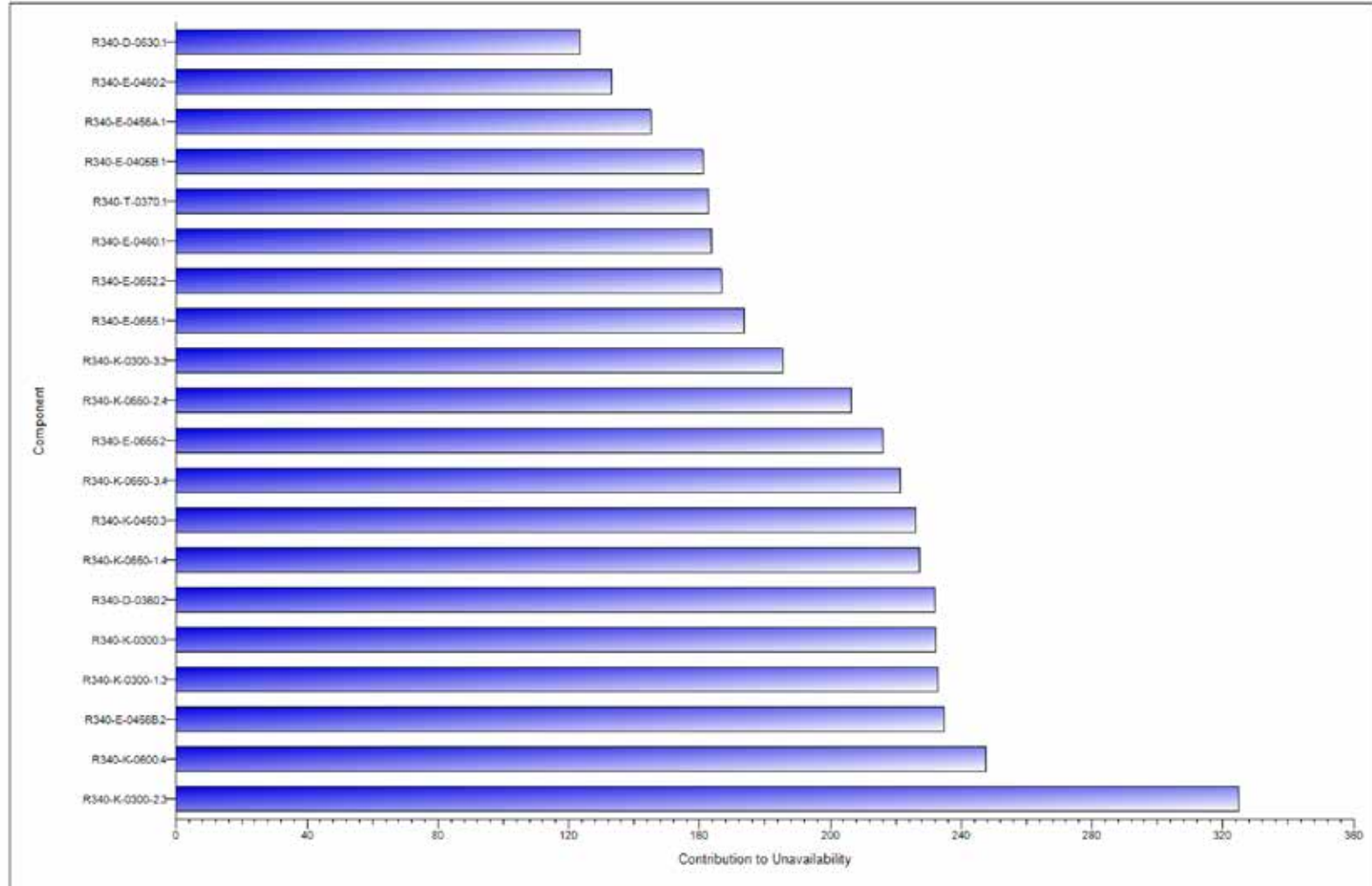
System profile





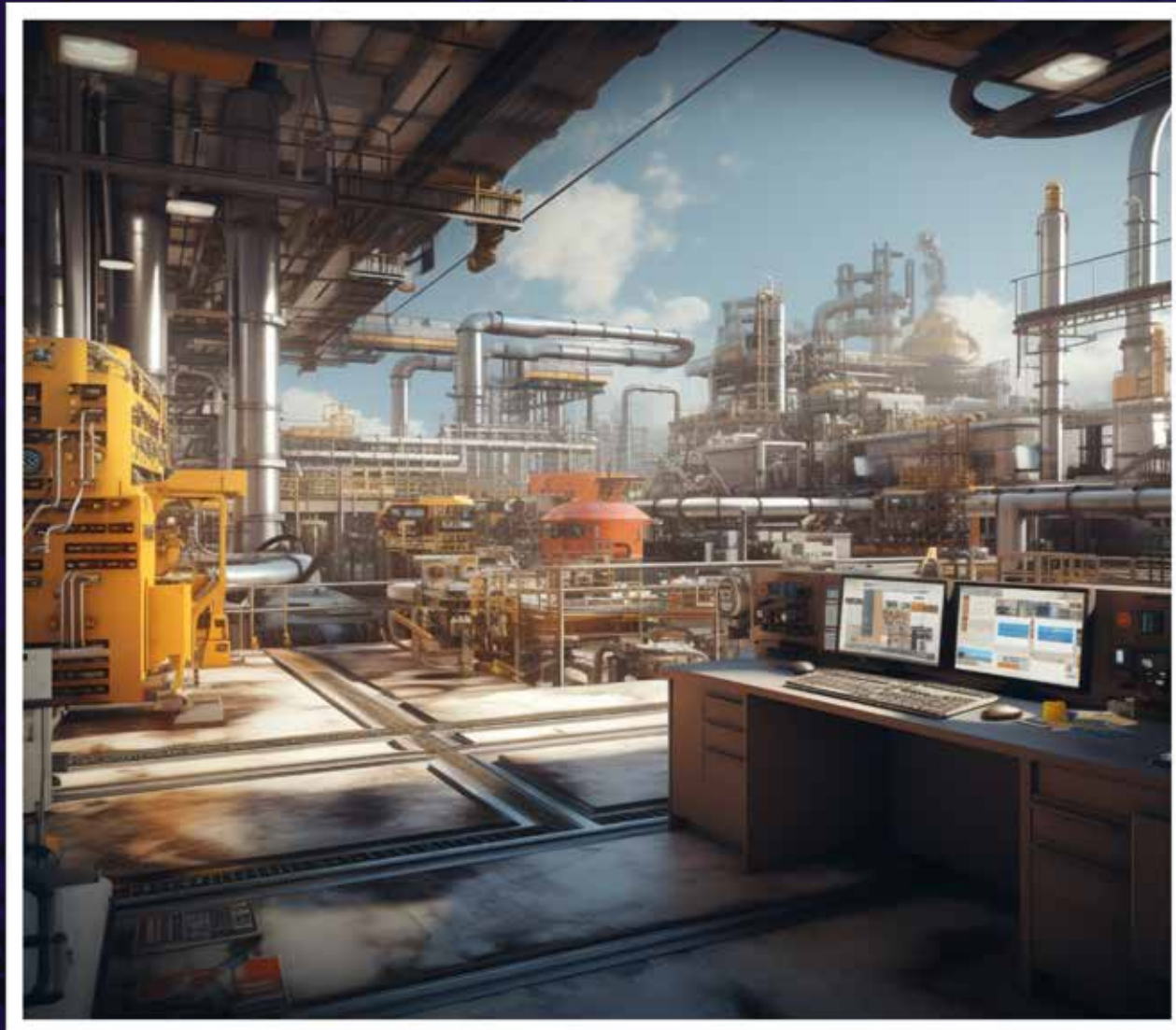
Case Study

Contribution

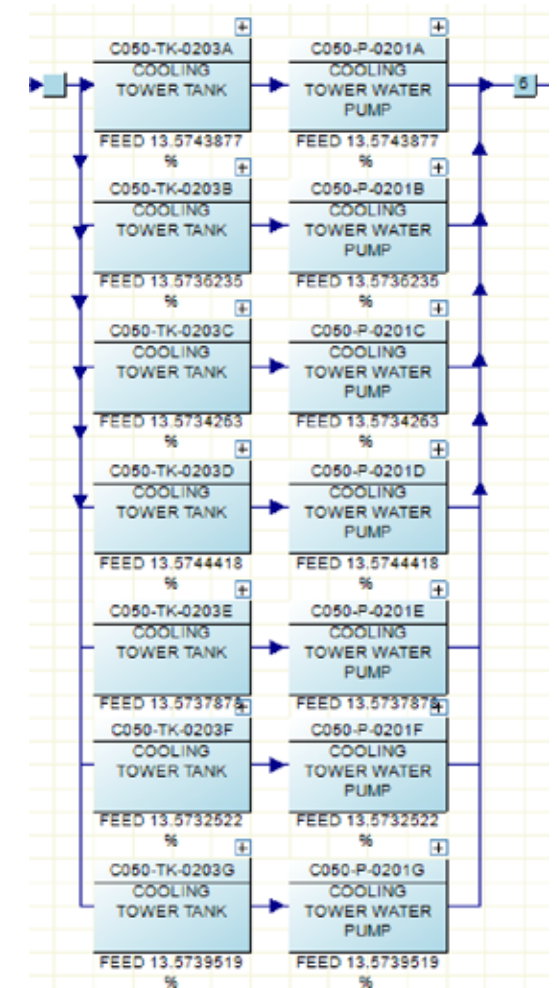
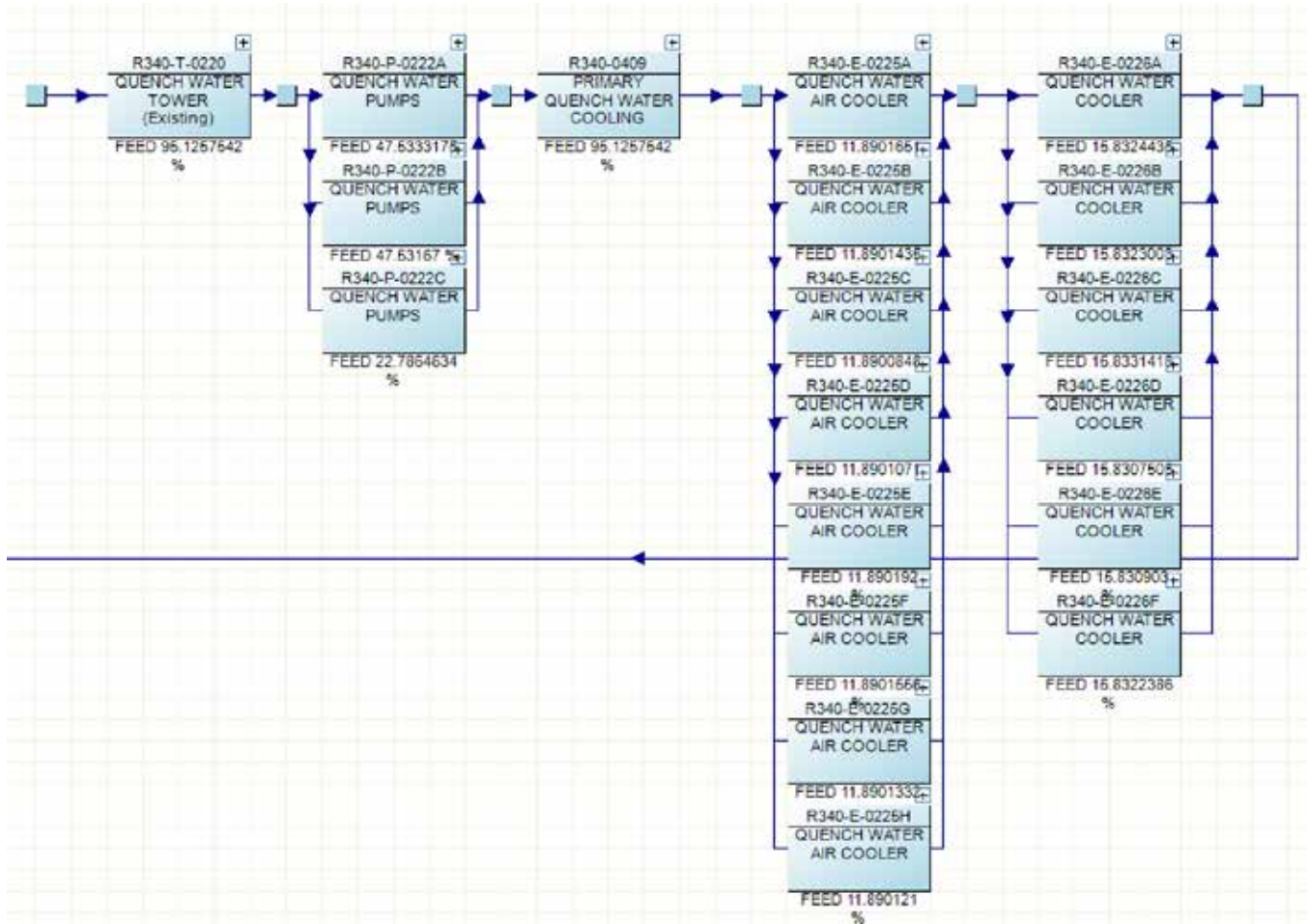




RBD Modelling & Techniques

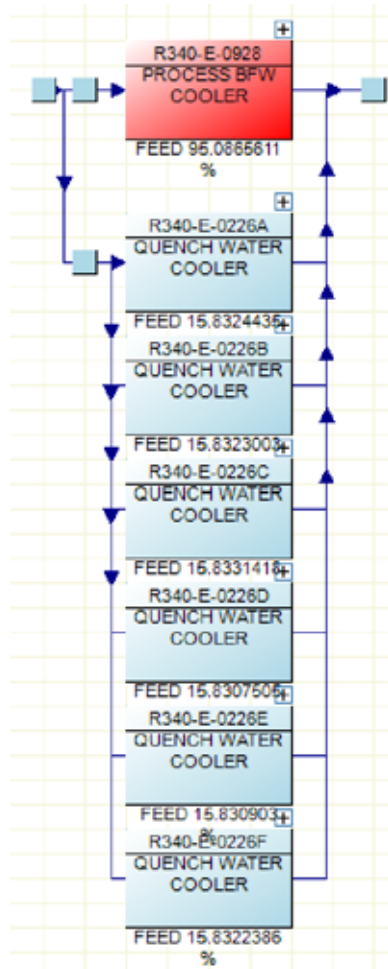


Redundancy Arrangements

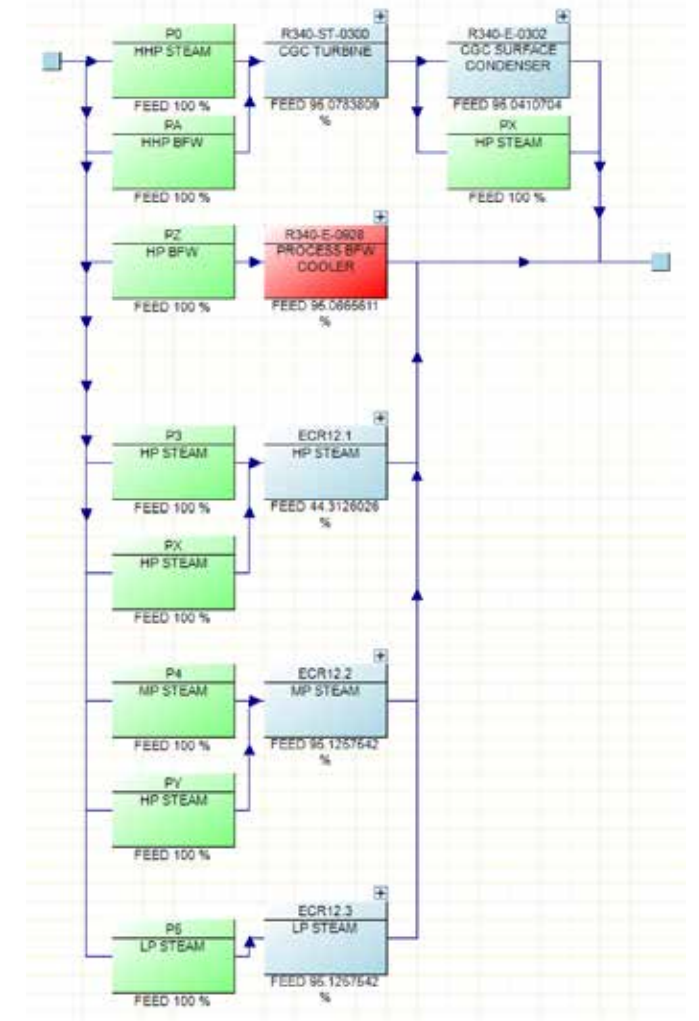


Common Assets

Exchanger in a steam system and product system

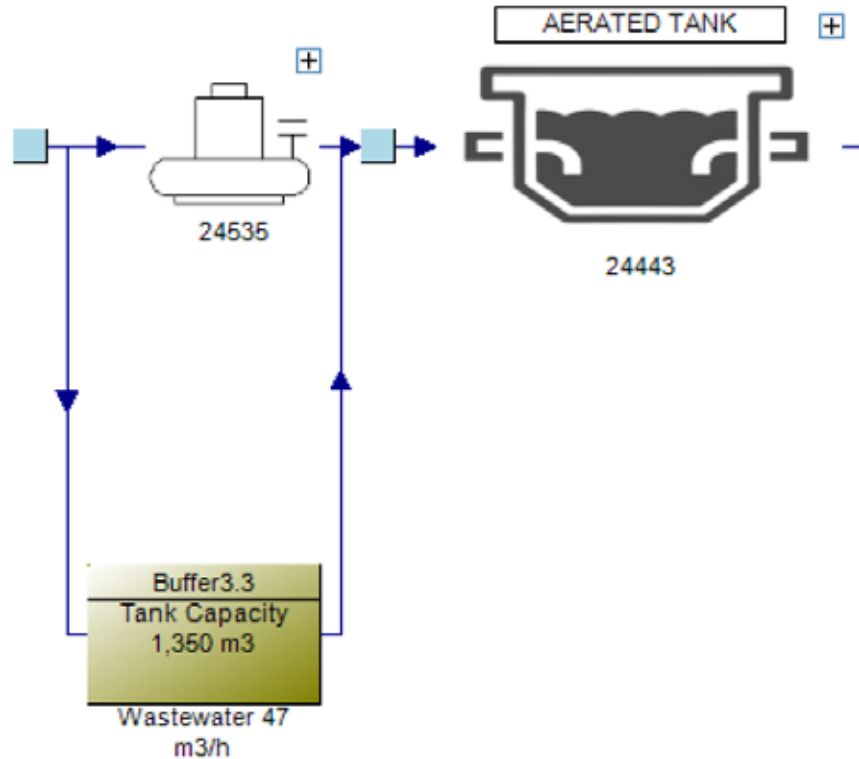


QUENCH WATER TOWER



STEAM DISTRIBUTION SYSTEM

Tank Storage and Buffer Capacity



TANK CAPACITY OF 1,350 m³

The screenshot shows the 'Failure Model Properties - Buffer' window with the following settings:

- General:** Distribution: Buffer, Weibull set: Not set
- Product:** Waste water
- Distribution parameters:** Buffer fill mode: Buffer fill rate independent of system state, Time to empty buffer: 8, Time to fill buffer: 2
- Weibull distribution:**

Eta-1: 8760	Beta-1: 2	Gamma-1: 0
Eta-2: 8760	Beta-2: 2	Gamma-2: 0
Eta-3: 8760	Beta-3: 2	Gamma-3: 0
- Failure apportionment:** Non-operating failure apportionment (%): 50, Non-operating ageing apportionment (%): 50, Start-up failure probability: 0
- Domant failure:**

TANK TAKES 8 HOURS TO EMPTY AND 2 TO FILL



Opportunistic Maintenance

Task Properties - PM463: Replace pump stator

General Advanced Rules Notes Optimization

Task enabled

Interval: 8760 Offset: 0 Fixed interval

Description: Replace pump stator

Task ID: PM463

Task duration: 2 Operational cost: 0

Ramp time: 0 Minimum age: 0

Task group: Not set

New Group... Edit Group...

Resources:

- MEC x 2
- 140298 x 1 STATOR, CAVITY PUMP, 056009G54A1215

Add... Add... Add... Edit... Remove

Copy Corrective Properties OK Cancel

PLANNED MAINTENANCE

Rule Properties

Type: Trigger task by state

State dependency type: RBD Block

Reference block: 25645

Reference block state: Out of service

Minimum elapsed time/age: 35000

Rule description:
If block 25645 is out of service trigger task if elapsed time/component age >= 35000

OK Cancel

OUT OF SERVICE

Phase Properties - Winter

General Notes

ID: Winter

Group: Not set

Description:

Duration: 2190

OK Cancel

PHASES FOR SEASONS

Block Properties - V.NVA.NVA-0002.1 : Waste water

General Rules Appearance Notes

Defaults

	Wastewater	Water (m3/h)	Sludge (m3/h)	Treated water
Max capacity:	47	0	0	0

Logic mode: Probabilistic

Standby mode: Hot

Load factor: 1

Inhibit all tasks (non-repairable and non-maintainable)

Use standby times to failure when operating

Rules

ID	Description
Rule 1	Set Wastewater capacity to 44 m3/h during phase Winter
Rule 2	Set Wastewater capacity to 46 m3/h during phase Spring
Rule 3	Set Wastewater capacity to 47 m3/h during phase Summer
Rule 4	Set Wastewater capacity to 46 m3/h during phase Autumn

Add... Edit... Move Up List Move Down List Remove

OK Cancel

CHANGING OF CAPACITY FOR WASTEWATER DURING SEASONS



Shutdowns, Turnarounds & Inspection

ID	Asset Type	E	Event Type	Failure	Failure Mode	MTBF	MTRR	Task Description
CMP1	Compressor, axial	4	Planned	Fixed	Compressor overhaul	87,600	336	Compressor major overhaul
CMP2	Compressor, centrifugal	4	Planned	Fixed	Compressor overhaul	87,600	336	Compressor major overhaul
CMP3	Compressor, reciprocating	5	Planned	Fixed	Compressor overhaul	87,600	336	Compressor major overhaul
PMP1	Pump, centrifugal	4	Planned	Fixed	Pump overhaul	43,800	48	Pump overhaul
PMP2	Pump, metering	2	Planned	Fixed	Pump overhaul	43,800	8	Pump overhaul
PMP3	Pump, reciprocating	4	Planned	Fixed	Pump overhaul	43,800	48	Pump overhaul
TNK1	Tank, cone roof	3	Planned	Fixed	Internal Inspection (T&I)	87,600	168	Internal Inspection (T&I)
EXC1	Exchanger, fin fan	4	Planned	Fixed	Internal Inspection (T&I)	43,800	48	Internal Inspection (T&I)
EXC2	Exchanger, shell and tube	6	Planned	Fixed	Internal Inspection (T&I)	43,800	168	Internal Inspection (T&I)
EXC2	Exchanger, shell and tube	7	Planned	Fixed	Flush exchanger	43,800	48	Flush exchanger
EXC3	Exchanger, plate	4	Planned	Fixed	Flush exchanger	43,800	24	Flush exchanger
HET1	Heater, direct fired	6	Planned	Fixed	Internal Inspection (T&I)	87,600	168	Internal Inspection (T&I)
VES1	Vessel, surge drum	3	Planned	Fixed	Internal Inspection (T&I)	43,800	168	Internal Inspection (T&I)
VES2	Vessel, flash drum	3	Planned	Fixed	Internal Inspection (T&I)	43,800	168	Internal Inspection (T&I)
VES3	Vessel, column	4	Planned	Degradation	Internals worn (trays)	43,800	96	Internals worn (trays)
VES3	Vessel, column	5	Planned	Fixed	Internal Inspection (T&I)	43,800	168	Internal Inspection (T&I)
VES4	Vessel, seperator	4	Planned	Fixed	Flush seperator	43,800	48	Flush seperator
VES6	Vessel, reactor	4	Planned	Degradation	Catalyst deterioration	43,800	336	Catalyst replace
VES6	Vessel, reactor	5	Planned	Fixed	Internal Inspection (T&I)	43,800	168	Internal Inspection (T&I)
TRB1	Turbine, steam, multistage	4	Planned	Fixed	Overhaul of blades	43,800	336	Overhaul
TRB2	Turbine, steam, single stage	4	Planned	Fixed	Overhaul of blades	43,800	168	Overhaul
VES7	Vessel, coalescer	3	Planned	Fixed	Internal Inspection (T&I)	43,800	48	Internal Inspection (T&I)
VES8	Vessel, stripper	2	Planned	Fixed	Internal Inspection (T&I)	43,800	168	Internal Inspection (T&I)
VES9	Vessel, distillation column	4	Planned	Fixed	Internal Inspection (T&I)	43,800	168	Internal Inspection (T&I)
VES10	Vessel, Molecular sieve dryer	3	Planned	Fixed	Internal Inspection (T&I)	43,800	168	Internal Inspection (T&I)



Shutdowns, Turnarounds & Inspection

Task Group Properties - 10 Yearly

General Predictive Data Rules Notes Tasks

ID: 10 Yearly

Type: Not set

Description:

Assign description

Enable associated tasks

Assign interval to associated tasks Fixed interval

Interval: 87600 Interval offset: 0

Efficiency factor: 1

Operational cost: 0

OK Cancel

TASK GROUP

Task Group Properties - 10 Yearly

General Predictive Data Rules Notes Tasks

Assign rules to associated tasks

Rules

ID	Description
Rule 1	Inhibit task during phase OPERATIONAL

Add... Edit... Move Up List Move Down List Remove

Note that assigned rules will replace any existing rules for associated tasks.

OK Cancel

RULES TO ONLY PERFORM TASKS DURING T&I

Task Group Properties - 10 Yearly

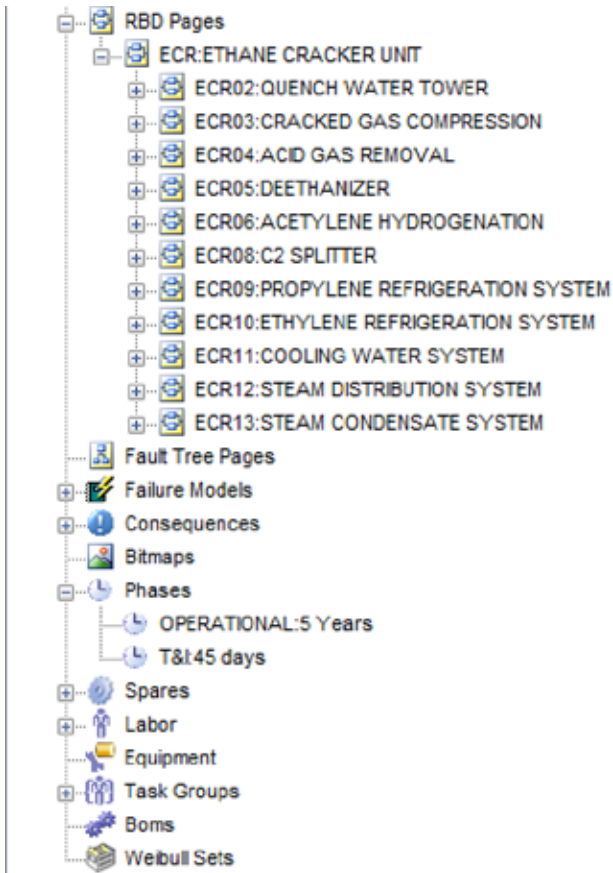
General Predictive Data Rules Notes Tasks

Failure Model	Task	Operation	Description	Enabled
CMP1.4	PM5		Compressor major overhaul	<input checked="" type="checkbox"/>
CMP2.4	PM9		Compressor major overhaul	<input checked="" type="checkbox"/>
CMP3.5	PM14		Compressor major overhaul	<input checked="" type="checkbox"/>
TNK1.3	PM27		Internal inspection	<input checked="" type="checkbox"/>

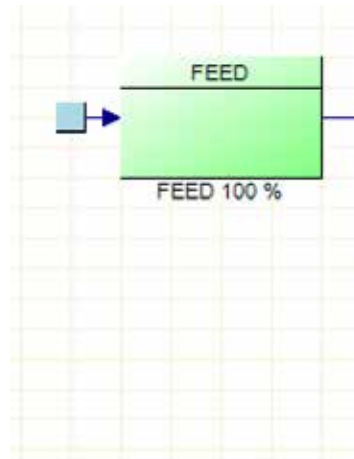
OK Cancel

TASKS IN GROUP

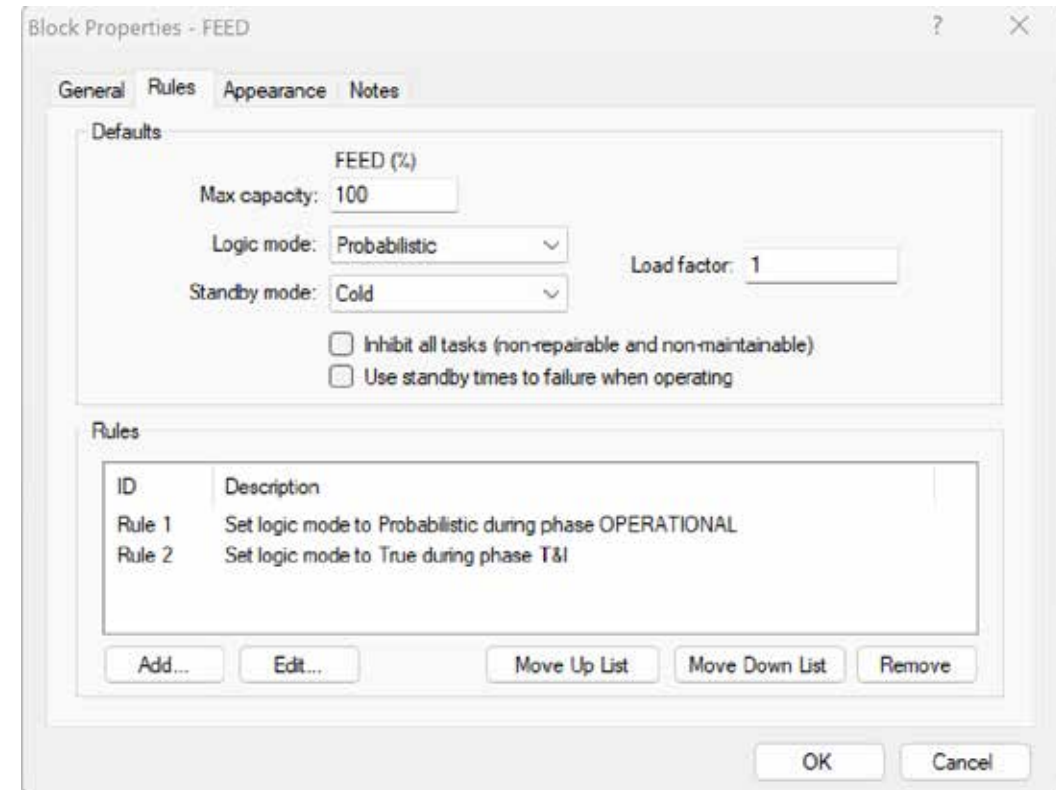
Shutdowns, Turnarounds & Inspection



SETUP PHASES

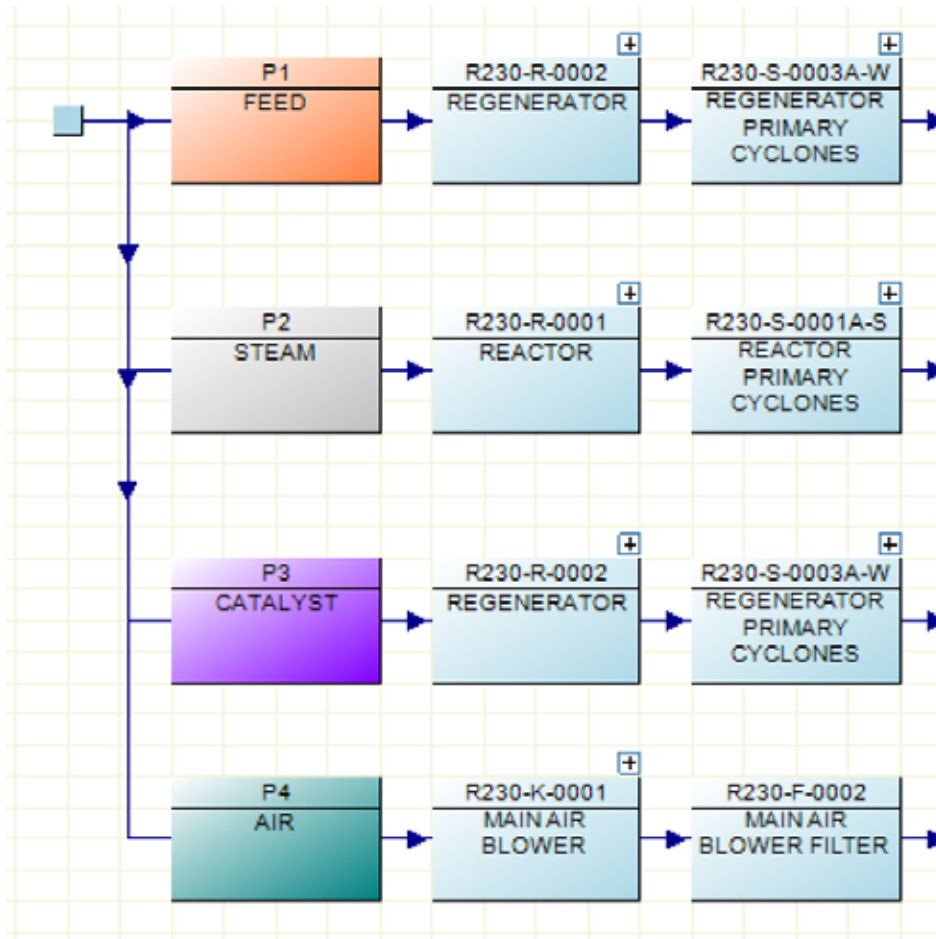


FEED BLOCK FOR MODEL CONSTRAINTS



SET RULES PER PHASE

Shutdowns, Turnarounds & Inspection



MULTIPLE FEED STREAMS

Block Properties - P1 : FEED

General Rules Appearance Notes

Defaults

	FEED (kg/h)	STEAM (kg/h)	CATALYST	AIR (kg/h)
Max capacity:	591561	0	0	0

Logic mode: Probabilistic

Standby mode: Hot

Load factor: 1

Inhibit all tasks (non-repairable and non-maintainable)

Use standby times to failure when operating

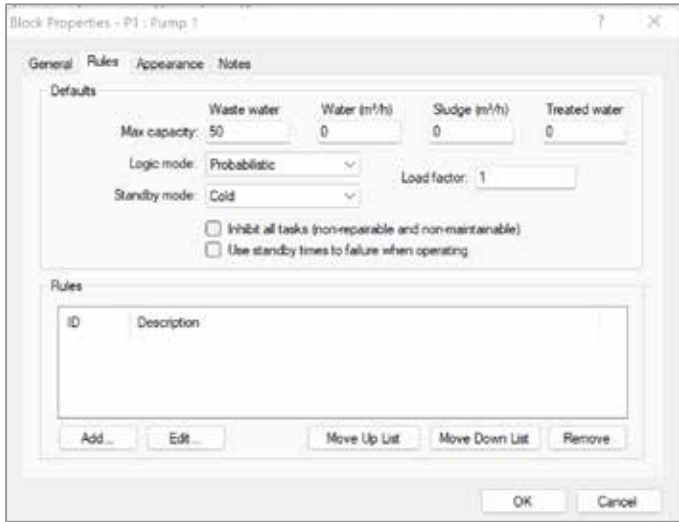
Rules

ID	Description
Rule 1	Set FEED capacity to 591561 kg/h during phase OPERATIONAL
Rule 2	Set FEED capacity to 0 kg/h during phase T&I

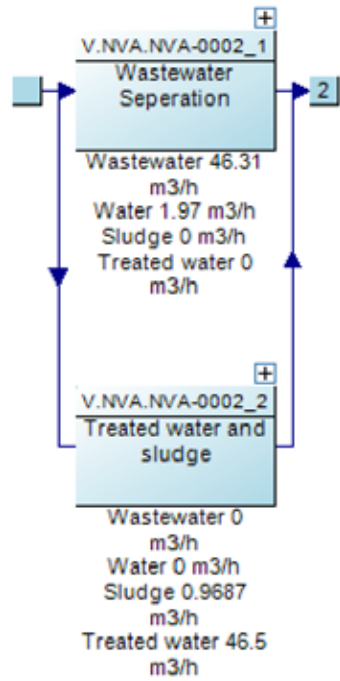
Add... Edit... Move Up List Move Down List Remove

OK Cancel

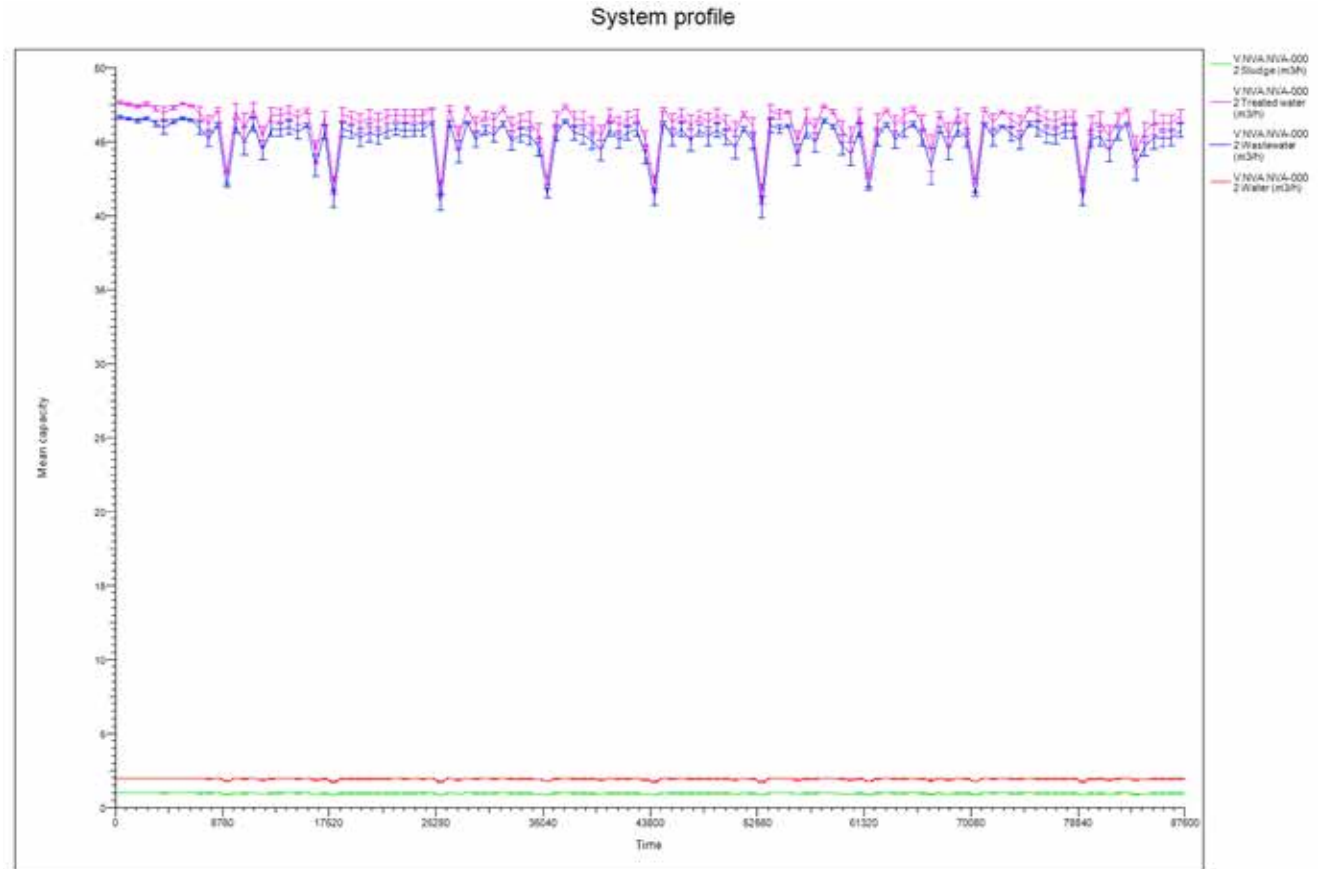
RULES TO SHUT OFF STREAMS DURING A SHUTDOWN



PRODUCT CAPACITY SETUP

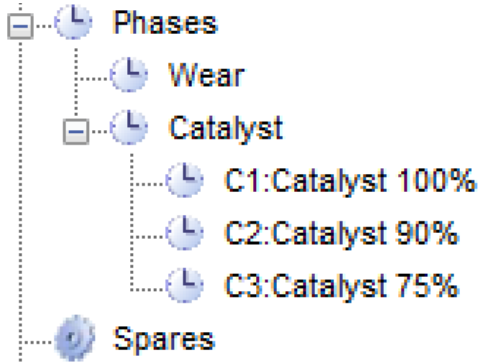


PARALLEL SYSTEMS



GRAPHICAL PRODUCTION OUTPUT OVER LIFECYCLE

Capacity Reduction



Phase Properties - C2 : Catalyst 90%

General Notes

ID: C2

Group: Catalyst

Description: Catalyst 90%

Duration: 8760

OK Cancel

Block Properties - R340-1-0220.4

General Rules Appearance Notes

Defaults

Max capacity: 1871

Logic mode: Probabilistic

Standby mode: Hot

Load factor: 1

Inhibit all tasks (non-repairable and non-maintainable)

Use standby times to failure when operating

Rules

ID	Description
Rule 1	Set QUENCH WATER capacity to 1871 m3/h during phase C1
Rule 2	Set QUENCH WATER capacity to 1684 m3/h during phase C2
Rule 3	Set QUENCH WATER capacity to 1403 m3/h during phase C3

Add... Edit... Move Up List Move Down List Remove

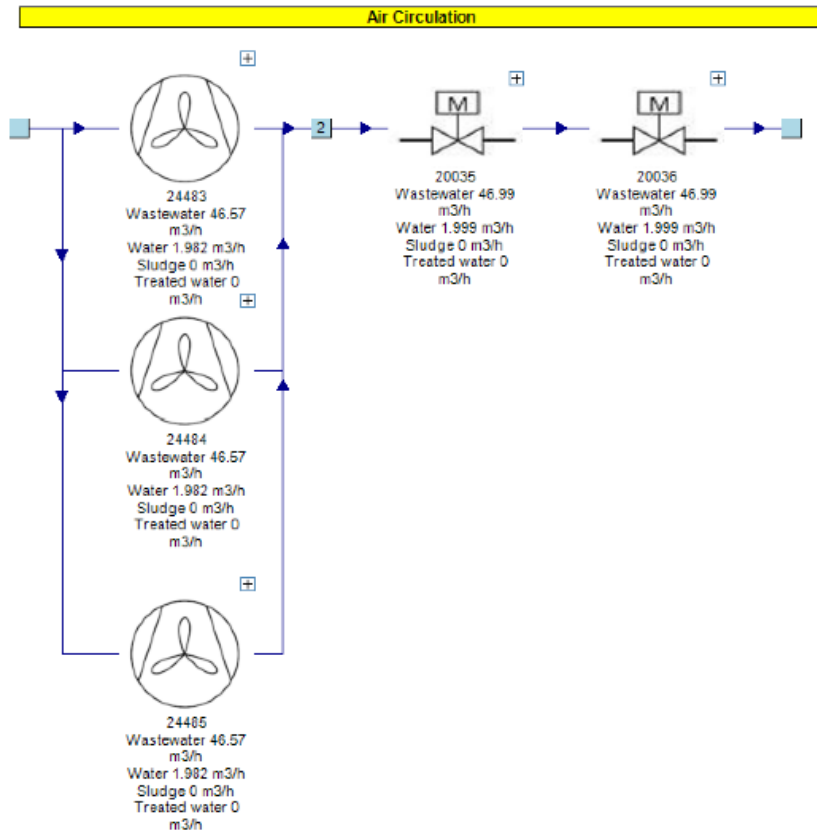
OK Cancel

SETUP PHASES

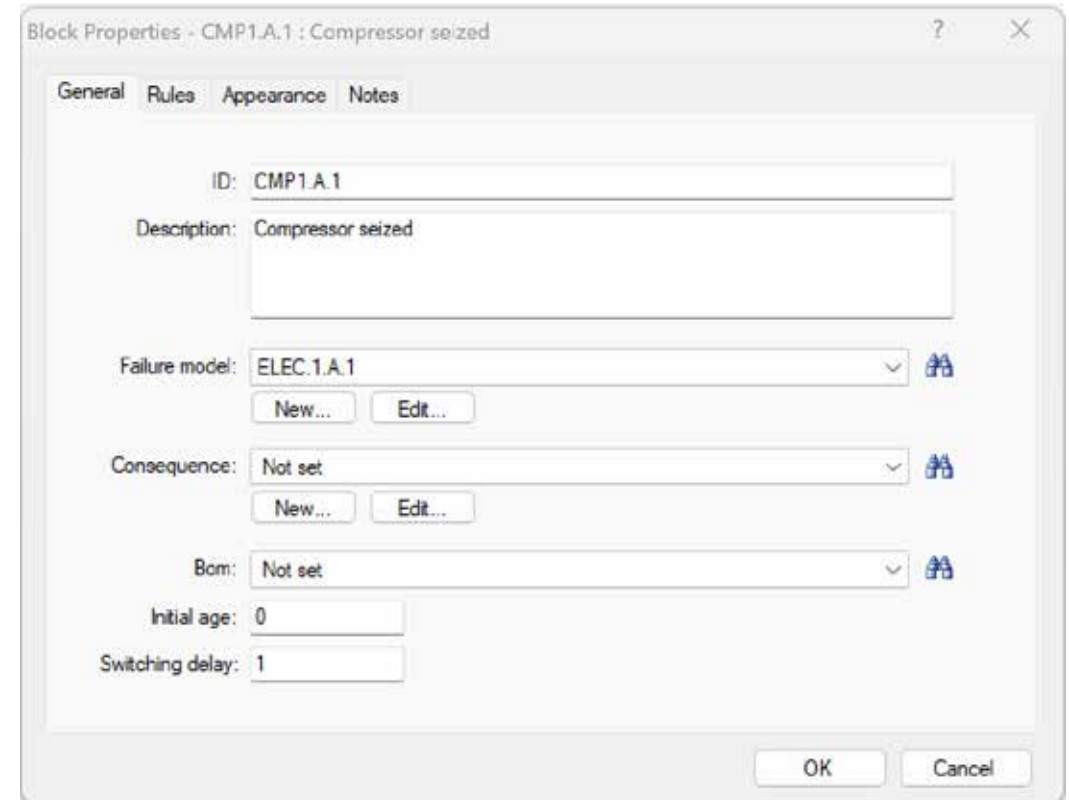
PHASES DEFINITION

SET RULES TO SHOW DECLINING
CAPACITY DUE TO CATALYST
DETERIORATING OVER TIME

Switching Delay



2 AIR BLOWERS ON DUTY WITH 1 IN STANDBY



1 HOUR SWITCHING DELAY WHEN 1 FAILS AND 3rd ENGAGES



Spare Part Optimisation

There are 3 spare holding strategies that are considered during this process, and they are:

- Onsite storage (level 1)
- Offsite storage at a local warehouse or spare part distributor (level 2)
- Direct from manufacturer (level 3)

Screenshot of the 'Spare Properties' dialog box for ID 140298. The dialog has tabs for General, Level 1, Level 2, Level 3, Repair Shop, Notes, and Optimization. The General tab is active, showing fields for ID (140298), Type (Not set), Description (STATOR, CAVITY PUMP, 056009G54A1216), Unit cost (1250), Unit volume (0), and Unit weight (0). OK and Cancel buttons are at the bottom right.

SPARE SETUP

Screenshot of the 'Spare Cost Optimization' dialog box. It contains a table with the following data:

ID	Level 1 Min	Level 1 Max	Level 1 Opt	Level 2 Min	Level 2 Max	Level 2 Opt	Sensitivity
140298	0	6	0	0	6	1	0.02805

Below the table are buttons: 'Set range for selected spare(s)...', 'Optimize selected spare(s)', and 'Accept recommendations for selected spare(s)'. A note '* out of date' is present. On the right are 'Select all', 'Abort', and 'Close' buttons.

SPARE INVENTORY OPTIMISATION



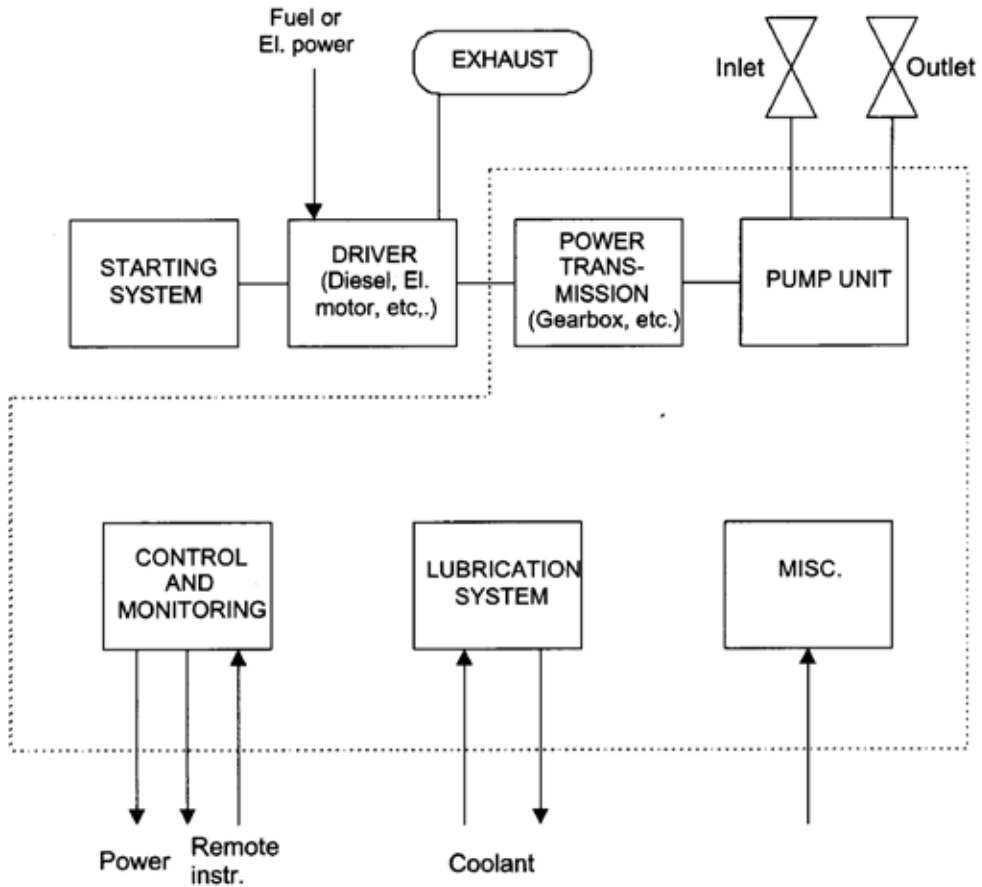
Industry and Site Data Integration





Industry Data Sources

- 1. OREDA** - Offshore REliability DAta Handbook
- 2. NPRD** - Non-electronic Parts Reliability Data (2023)
- 3. ERDA** - Electronic Reliability Design Handbook
- 4. FAID** - Failure and Incident Database
- 5. PERD** - Process Equipment Reliability Database
- 6. FMD** - Failure Mode Database
- 7. ECSS** - European Space Agency's European Cooperation for Space Standardization Database
- 8. SDR** - U.S. FAA's Service Difficulty Reports
- 9. NTSB** - National Transportation Safety Board databases
- 10. WANO** - World Association of Nuclear Operators WANO database
- 11. INMPO** - Institute of Nuclear Power Operations INPO database
- 12. ICCFD** - International Common-Cause Failure Database



PUMP				
Power transmission	Pump	Control and Monitoring	Lubrication system	Miscellaneous
<ul style="list-style-type: none"> • Gearbox/var. drive • Bearing • Seals • Lubrication • Coupling to driver • Coupling to driven unit • Instruments 	<ul style="list-style-type: none"> • Support • Casing • Impeller • Shaft • Radial bearing • Thrust bearing • Seals • Valves & piping • Cylinder liner⁵ • Piston • Diaphragm⁶ • Instruments 	<ul style="list-style-type: none"> • Instruments • Cabling & junction boxes • Control unit • Actuating device • Monitoring • Internal power supply • Valves 	<ul style="list-style-type: none"> • Instruments • Reservoir w/heating system • Pump w/motor • Filter • Cooler • Valves & piping • Oil • Seals 	<ul style="list-style-type: none"> • Purge air • Cooling/heating system • Filter, cyclone • Pulsation damper



OREDA

Taxonomy no		Item								
1.3.1		Machinery Pumps Centrifugal								
Population	Installations	Aggregated time in service (10 ⁶ hours)					No of demands			
		Calendar time *		Operational time †			10340			
350	59	13.9546		5.7455						
Failure mode	No of failures	Failure rate (per 10 ⁶ hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Critical	464*	0.00	21.60	124.23	67.21	33.25	39.7	1.0	57.6	1025.0
	464†	0.12	70.52	284.09	106.81	80.76				
Breakdown	37*	0.00	1.20	1.67	7.82	2.65	16.4	3.0	57.1	766.0
	37†	0.00	3.70	21.16	11.38	6.44				
Erratic output	2*	0.00	0.15	0.79	0.54	0.14	19.8	11.0	39.5	68.0
	2†	0.00	0.46	2.22	0.92	0.35				
External leakage - Process medium	77*	0.00	2.25	5.52	11.84	5.52	30.2	2.0	42.0	444.0
	77†	0.00	7.04	38.07	17.67	13.40				
External leakage - Utility medium	46*	0.00	1.61	2.94	9.28	3.30	16.0	2.0	29.8	90.0
	46†	0.00	4.81	26.68	13.65	8.01				
Fail to start on demand	42*	0.01	2.28	8.52	3.14	3.01	55.8	1.0	63.0	551.0
	42†	0.02	13.74	55.88	21.10	7.31				
Fail to stop on demand	2*	0.00	0.13	0.65	0.57	0.14	3.5	3.0	3.5	4.0
	2†	0.00	0.38	1.55	0.58	0.35				
High output	3*	0.00	0.69	3.58	2.77	0.21	-	1.0	3.3	6.0
	3†	0.00	2.49	13.73	6.44	0.52				
Internal leakage	3*	0.00	0.16	0.87	0.57	0.21	188.0	36.0	90.7	188.0
	3†	0.00	0.56	2.63	1.08	0.52				
Low output	40*	0.00	2.58	3.33	17.49	2.87	38.2	3.0	45.3	508.0
	40†	0.00	4.68	7.79	27.92	6.96				
Noise	4*	0.00	0.25	1.29	0.57	0.29	25.0	16.0	67.3	122.0
	4†	0.03	0.78	2.34	0.80	0.70				
Other	8*	0.00	0.60	3.20	2.68	0.57	275.5	2.0	424.5	734.0
	8†	0.00	1.85	8.07	3.14	1.39				
Overheating	5*	0.11	0.36	0.72	0.19	0.36	183.2	3.0	265.0	1025.0
	5†	0.00	0.00	0.00	0.00	0.00				



Asset Library

OREDA DATA IN ELECTRONIC FORMAT

The screenshot displays the ASSETCORE XL software interface. On the left is a navigation menu with options: Dashboard, Asset Library, Digitise Assets, Defect Elimination, RCM Design, RAM Modeling, Data Analytics, and System Setup. The main area is titled 'OREDA' and contains a list of asset types such as Compressor, Exchanger, Heater, Mixer, Pump, Tank, Turbine, and Vessel. The 'Abnormal instrument reading' failure mode is selected and highlighted.

The 'Details' section for the selected failure mode shows:

- Failure Mode ID: PMP1.1.A.1
- Failure Mode Description: Abnormal instrument reading
- Component: Select
- Characteristic: Select
- Symptom: Select
- Custom:
- Distribution: Weibull Exponential
- MTTF: 75472
- Stopped: Yes No

A 'Failure Rate' graph is shown with a horizontal line at approximately 0.15 on the y-axis (ranging from -1 to 1) and x-axis values from 0 to 75472.

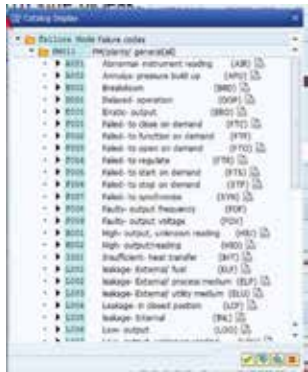
The 'Tasks' section contains a table:

1	2	3	4	5	Type	Task	Duration	Subre	Interval	P.F.	PHM	Output	Delete
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Corrective	Repair/replace parts	8.00	MEQ2	0	0		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select			Select				<input type="checkbox"/>	<input type="checkbox"/>

A 'Save' button is located at the bottom right of the tasks section.



Site Data



SYMPTOM
or FM
OREDA

Descriptions
helps for
data mining

#OmaintecCon

Display PM Notification: Corrective Maint Req

1. Type: M2 3. Description: 120/repair G-301B lube oil leak, 11. Long Text: [icon]

Notification: 20440677 M2 120/repair G-301B lube oil leak, [icon]

Notific. Status: NOCO ORAS [icon] MCOM

Order: 11255761 [icon]

Notification FRACAS Data Area of Responsibility Location data Item History Enhancement

Reference object

Functional loc.: 120-CR-DI0-G0301 G301 BOTTOM PUMPS COL-19

Equipment: 2825331 G301B STABILIZER 19 CENTRFG BOTTOMS P...

Assembly: [icon]

2. Equipment Number

Start/End Dates

Required Start: 01/20/2017 07:41:17 Priority: Med-Sch within 10day

Required End: 03/21/2017 07:41:17 Breakdown

4. Failure Mode

Subject

Failure Mode: FM041 L001 leakage- External/ fuel (ELF)

Description: 120/repair G-301B lube oil leak, [icon]

Subject Long Text

01/10/2017 08:43:07 UTC+3 M. Gharwi (GHARWIMH) Phone +966 13 572-3293
120/repair G-301B lube oil leak, ALSO TO IMPLEMENT ME&FA RECOMMENDATION

5. Malfunction Start /End Data 6. Breakdown Indicator

Malfunction data

Malfunc. start: 01/05/2017 00:00:00 Breakdown

Malfunc. end: 01/06/2017 00:00:00 Breakdown dur.: 24.00 H

Equipment at
tag level

Equipment
assigned to
classifications
or asset types

Malfunction
start is the
MTBF
calculated
date

Figure [1-A] – Fields Evaluated in SAP

MEAN TIME TO REPAIR (MTTR) = 24.0 H



Site Data

Failure mode:

CASING-BOTTOM
TWISTED CAUSED BY
DESIGN_INCORRECT



Figure [1-B] – Fields Evaluated in SAP

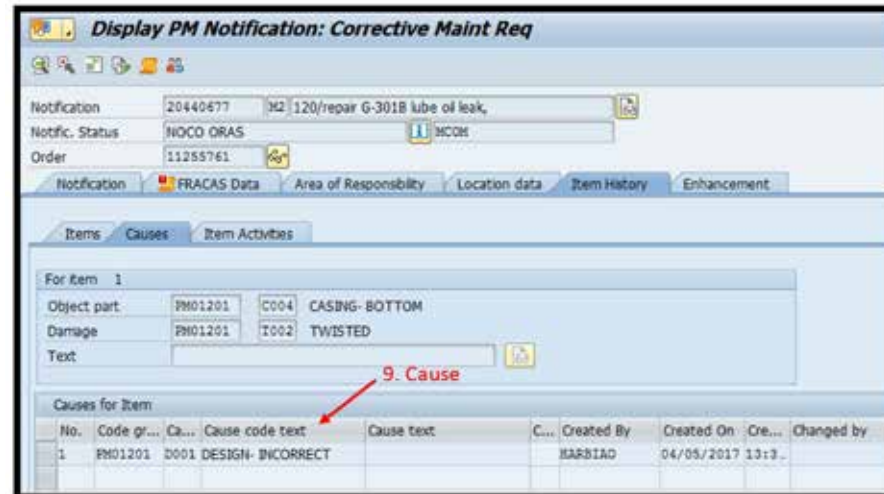
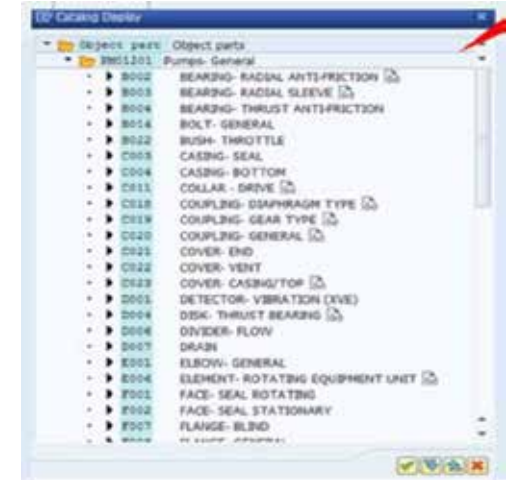
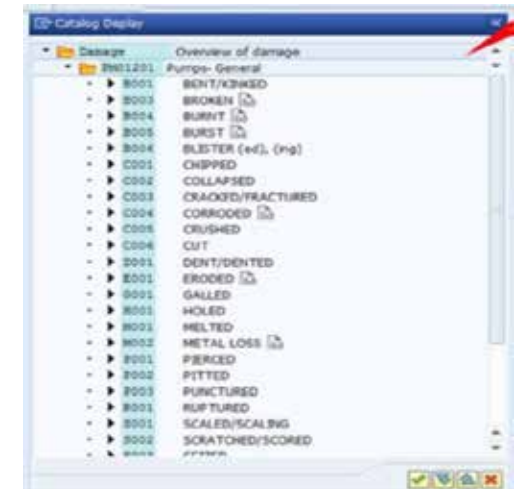


Figure [1-C] – Fields Evaluated in SAP



Notification Status Completed

- Notification
- Functional location
- Equipment
- Description
- Failure mode (OREDA code)
- Malfunction start/end
- Breakdown indicator
- Breakdown duration and units

Asset Hierarchy

- Functional location
- Equipment
- Classification (Pumps, centrifugal) as per OREDA
- Criticality

Combined Notification Repair list: Selection of Notifications

Notification status: Outstanding Postponed In process Completed In profit Cancelled

Notification selection:

Notification	to	
Notification type	to	int
Functional location	to	1001
Equipment	to	
Material	to	
Serial number	to	
ADSL, device data	to	
Order	to	
Notification date	to	12/01/2004
Priority	to	

Location (functional assignment/object):

Plant	to	
Location	to	
Room	to	
Sort field	to	
Plant section	to	
ABC indicator	to	
Cost Center	to	
Company Code	to	
Business Area	to	
Asset	to	

Activities:

Activity text	to	
Activity	to	
Activity code	to	

Item data/case data:

Item text	to	
Problem	to	
Damage Code	to	
Object part	to	
Object part code	to	
Cause text	to	
Cause	to	
Cause code	to	

General data/administrative data:

Description	to	
Created By	to	
Created On	to	
Notification Time	to	01/01/04
Reference date	to	01/01/04
Coding	to	
Coding Code	to	
Priority	to	
Reported by	to	
Changed by	to	
Changed On	to	
Status included	to	
Status excluded	to	
Main work center	to	
Plant for WorkCenter	to	
Planning plant	to	
Planner group	to	
Required Start	to	
Required End	to	01/01/2005

Figure [4] – Z10110 SAP Screen



Site Data

Combined Notification Repair Hist: List of Notifications

Notification Long Text

5	Notification	Notif.date	Description	Item text	Item Text	Object Part	Code group	Obj Code	Obj.part	CodeGrp	Cause	Cause text	Cause Text	Activity Text	Activity text
	11220997	07/10/2017	To verify H2S and LEL materials			PM011	PM011	Z099	Z099	PM011	PM011	new installation	new installation		
	11220997	07/10/2017	To verify H2S and LEL materials			PM011	PM011	Z099	Z099					new	new
	11222070	07/13/2017	120/Hydrojetting for FinFan cooler cells												
	11227334	08/01/2017	120/G-5 M/Seal to verify materials			PM01201	PM01201	F001	F001	PM01201	PM01201				
	11227334	08/01/2017	120/G-5 M/Seal to verify materials			PM01201	PM01201	F001	F001					see attche	see attche
	11238290	09/12/2017	120/To address 3rd QSI finding			PM01213	PM01213	S017	S017					see	see
	11238290	09/12/2017	120/To address 3rd QSI finding			PM01213	PM01213	S017	S017	PM01213	PM01213	union leak result in cor.	union leak result in cor.		
	11249881	10/24/2017	120/PIB-13 UPS system major PM check			PM011	PM011	C002	C002	PM011	PM011				
	11249881	10/24/2017	120/PIB-13 UPS system major PM check			PM011	PM011	C002	C002						
	11251314	10/29/2017	120/PIB-12 to verify VMS materials	work canceled.	work canceled.	PM011	PM011	K001	K001	PM011	PM011	canceled	canceled		
	11251314	10/29/2017	120/PIB-12 to verify VMS materials	work canceled.	work canceled.	PM011	PM011	K001	K001					canceled	canceled
	11251315	10/29/2017	120/PIB-13 to verify VMS materials	canceled	canceled	PM011	PM011	K001	K001					canceled	canceled
	11251315	10/29/2017	120/PIB-13 to verify VMS materials	canceled	canceled	PM011	PM011	K001	K001	PM011	PM011	canceled	canceled		
	11267264	12/24/2017	120/GT-9 chest valve replacement												
	20416646	05/30/2016	120/COL-16 AJT2117 NEED CALIPRATI			PM011	PM011	A002	A002	PM011	PM011	CALIBRATION (adjust	CALIBRATION (adjust		
	20416646	05/30/2016	120/COL-16 AJT2117 NEED CALIPRATI			PM011	PM011	A002	A002					CALIBRATED	CALIBRATED
	20416693	05/30/2016	120/EM302G1 START STOP BROKEN-P			PM01202	PM01202	W007	W007						
	20416693	05/30/2016	120/EM302G1 START STOP BROKEN-P			PM01202	PM01202	W007	W007	PM01202	PM01202				
	20416695	05/30/2016	120/MOV1253 NOT WORKING-PMOR			PM01220	PM01220	S033	S033						
	20416695	05/30/2016	120/MOV1253 NOT WORKING-PMOR			PM01220	PM01220	S033	S033	PM01220	PM01220				
	20417283	06/05/2016	120/EM302D1 NOT WORKING -PMOR			PM01202	PM01202	S027	S027						
	20417283	06/05/2016	120/EM302D1 NOT WORKING -PMOR			PM01202	PM01202	S027	S027	PM01202	PM01202				
	20417285	06/05/2016	120/EM302H1 TERMINAL BOX BROKEN-	Broken Terminal box	Broken Terminal box	PM01202	PM01202	B026	B026	PM01202	PM01202	Broken Terminal box	Broken Terminal box		
	20417285	06/05/2016	120/EM302H1 TERMINAL BOX BROKEN-	Broken Terminal box	Broken Terminal box	PM01202	PM01202	B026	B026					Broken Ter.	Broken Ter.
	20417323	06/05/2016	120/Thrust bearing V 120-G-14			PM01201	PM01201	B004	B004					see attach	see attach
	20417323	06/05/2016	120/Thrust bearing V 120-G-14			PM01201	PM01201	B004	B004	PM01201	PM01201	WATER IN LUBE OIL	WATER IN LUBE OIL		
	20420316	07/11/2016	120/G-13/upnormal sound/ need repair			PM01203	PM01203	P027	P027	PM01203	PM01203	air inside the pump	air inside the pump		
	20420316	07/11/2016	120/G-13/upnormal sound/ need repair			PM01203	PM01203	P027	P027					see attach	see attach

Figure [5] – SAP ZI0110 Report



Site Data

DATA ANALYTICS

ASSETCORE XL Demonstration English Paul Douglas

Dashboard | Asset Library | Digitise Assets | Defect Elimination | RCM Design | RAM Modeling | **Data Analytics** | Asset Performance | Work History | Downtime Tracking | Spare Part Analysis | CBM Data | System Setup

Filter

Asset Type: PUMP A
 Asset: Select
 Component: Select
 Failure Mode: Select
 Install Date:
 MTBF:
 Generate Weibull

Total History by Asset

Total History by Asset Type

Total History by Failure Mode

Work History Details

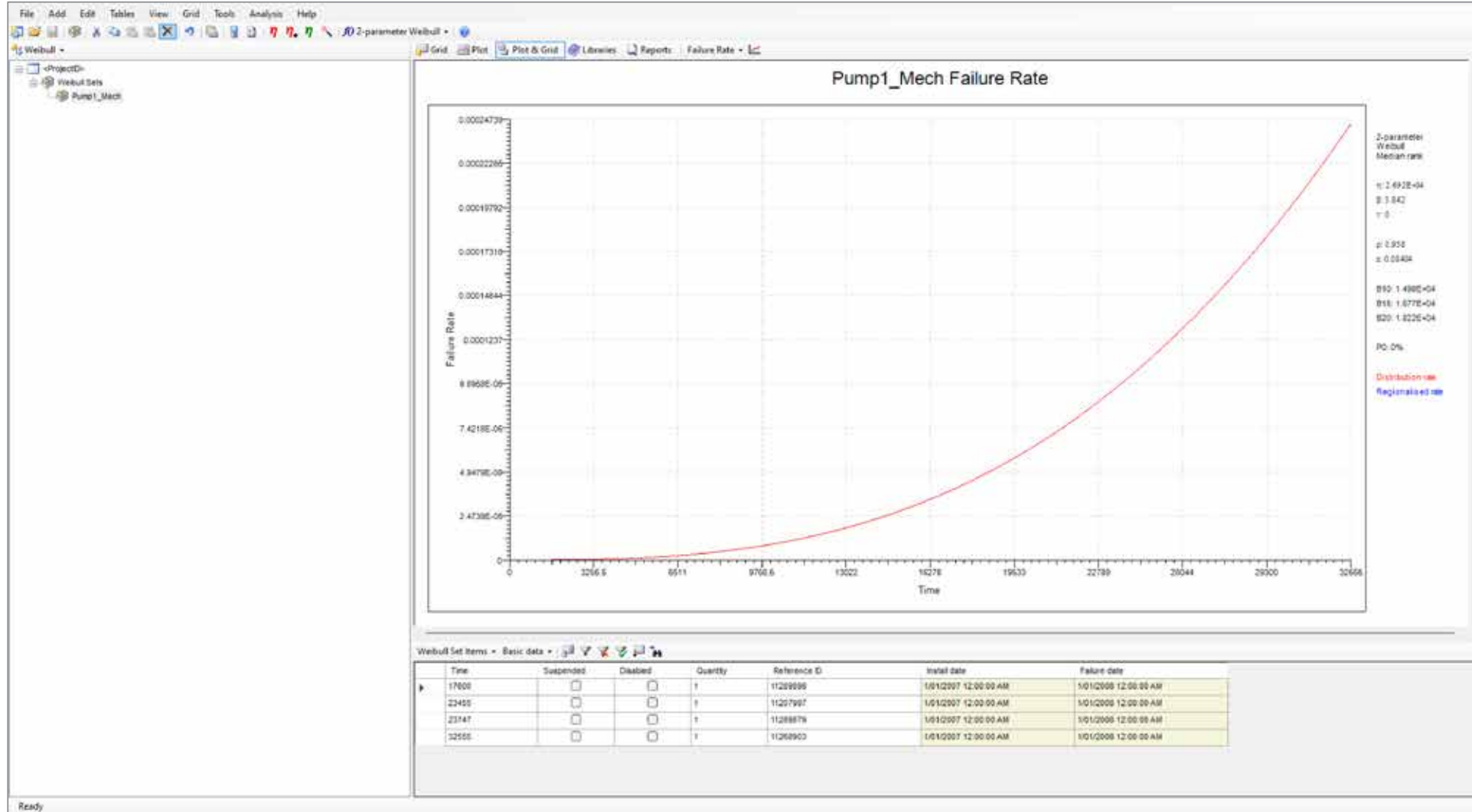
<input type="checkbox"/>	Edit	Id	Description	Asset	Asset Type	Object	Failure Mode	Failure
<input type="checkbox"/>		80000468	Repair Juice Guard	4110B-PP001	PUMP A	Shaft, pump	Shaft bent	8/06/20
<input type="checkbox"/>		80000430	Inspect Condition of Lube	4110B-PP001	PUMP A	Bolts, mounting	Mounting degradation	22/06/21
<input type="checkbox"/>		80000392	Cracktest Roller	4110B-PP001	PUMP A	Bolts, mounting	Mounting degradation	13/07/21
<input type="checkbox"/>		80000354	Connect Spray Lube	4110B-PP001	PUMP A	Bolts, mounting	Mounting degradation	29/07/21
<input type="checkbox"/>		80000315	Overhaul pump	4110B-PP001	PUMP A	Seal, pump, mechanical	Mechanical seal worn	9/08/20
<input type="checkbox"/>		80000278	Excess product leakage	4110B-PP001	PUMP A	Seal, pump, mechanical	Mechanical seal worn	19/08/21
<input type="checkbox"/>		80000240	Refurbish / Renew Nose Plates	4110B-PP001	PUMP A	Liner, pump	Liner worn	30/08/20
<input type="checkbox"/>		80000202	Remove Feed Hopper	4110B-PP001	PUMP A	Bearing, ball	Bearing seized	8/09/20
<input type="checkbox"/>		80000164	Install Bottom Nose Plate	4110B-PP001	PUMP A	Bearing, ball	Bearing seized	22/09/21
<input type="checkbox"/>		80000126	Inspect West Flender Gears	4110B-PP001	PUMP A	Bearing, ball	Bearing seized	30/09/20
<input type="checkbox"/>		80000088	Repair Deflector Plate	4110B-PP001	PUMP A	Coupling, rubber	Coupling worn	28/10/21
<input type="checkbox"/>		80000050	Fit new prox switches	4110B-PP001	PUMP A	Bearing, ball	Bearing worn	21/11/21
<input type="checkbox"/>		80000012	Overhaul pump	4110B-PP001	PUMP A	Bearing, ball	Bearing worn	18/12/21

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Site Data

WEIBULL SETS





Site Data

WEIBULL SETS

OREDA data is replaced over time with site data from SAP Notification history

The screenshot displays the AvSim software interface. On the left, a tree view shows the project structure under 'Project0', including 'RBD Pages', 'Fault Tree Pages', and 'Failure Models'. A blue bracket groups the 'Failure Models' items, with the text 'OREDA Data' next to it. A red arrow points from the 'Weibull set: Pump1_Mech' dropdown in the 'Failure Model Properties' dialog box to the 'Pump1_Mech' item in the tree view, with the text 'Site Data' next to it. The main workspace shows a sequence of four failure events: 'J11-G-0001A M/S Mechanical seal failure', 'J11-G-0001A M/I Motor issues', 'J11-G-0001A M Mechanical issues', and 'J11-G-0001A V/I Vibrational issues'. Each event box lists its MTTF, MTTR, and Product 76 MBSPO. The 'Failure Model Properties' dialog box for 'Pump1_MECH' is open, showing the 'Weibull' distribution type and the 'Weibull set' dropdown menu.

Event	MTTF	MTTR	Product 76 MBSPO
J11-G-0001A M/S Mechanical seal failure	30660	48	MBSPO
J11-G-0001A M/I Motor issues	122640	80	MBSPO
J11-G-0001A M Mechanical issues	175200	48	MBSPO
J11-G-0001A V/I Vibrational issues	17520	48	MBSPO

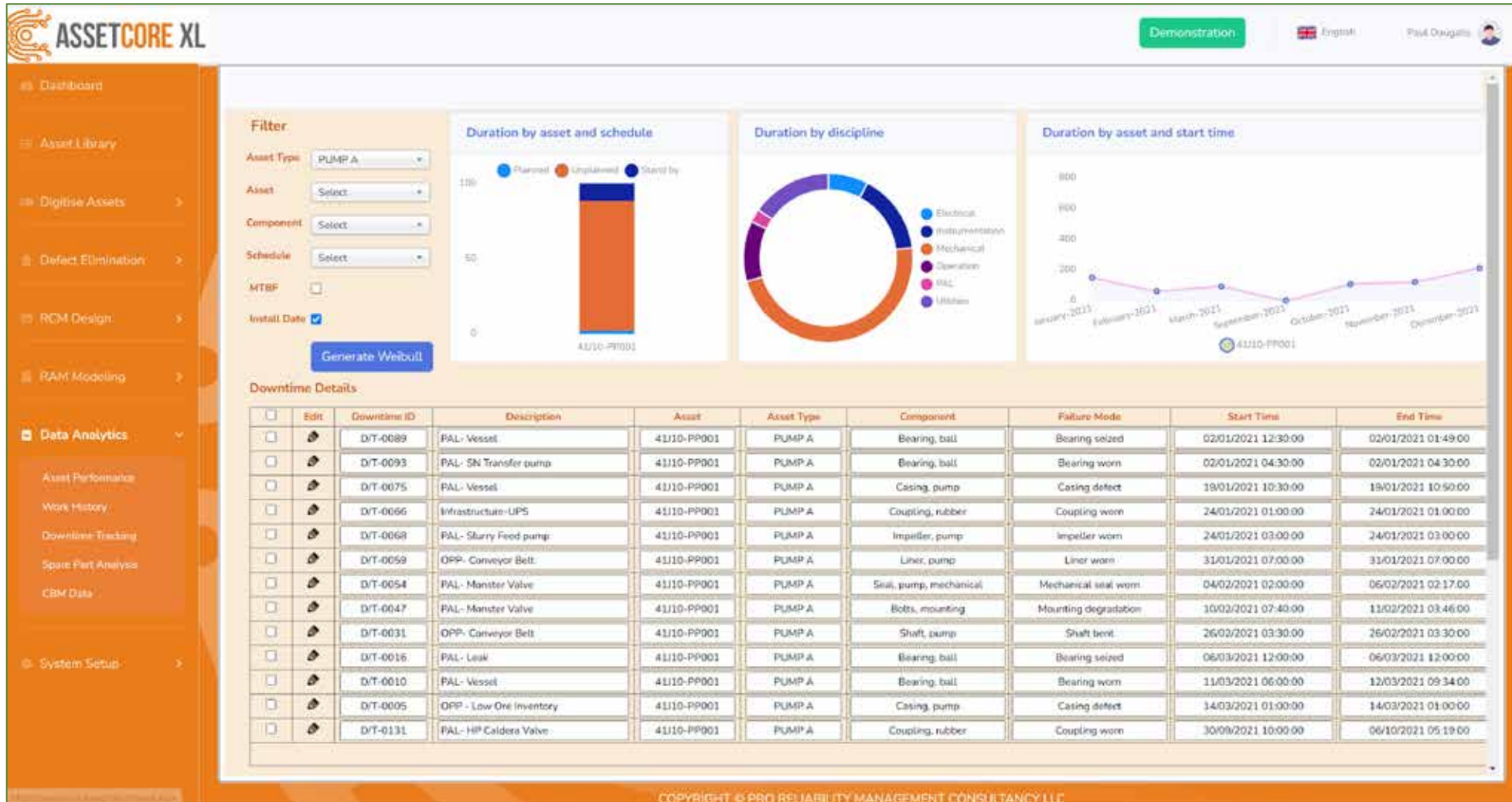
Weibull distribution		
Beta-1: 26920	Beta-1: 3.842	Gamma-1: 0
Beta-2: 8760	Beta-2: 2	Gamma-2: 0
Beta-3: 8760	Beta-3: 2	Gamma-3: 0

Non-operating failure apportionment (%): 50 Dormant failure

Non-operating ageing apportionment (%): 50

Start-up failure probability: 0


DOWNTIME DATA





Site Data

SPARE PART USAGE


Demonstration
English
Paul Douglas

Filter

Asset Type:

Asset:

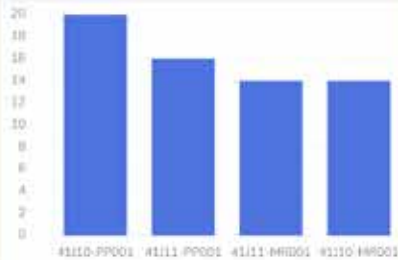
Component:

Spare Part:

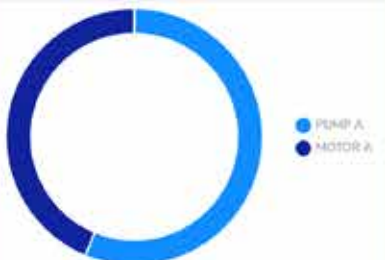
Install Date:

Generate Weibull


Total History by Asset



Total History by Asset Type



Total History by Spare Part



Spare Part Details

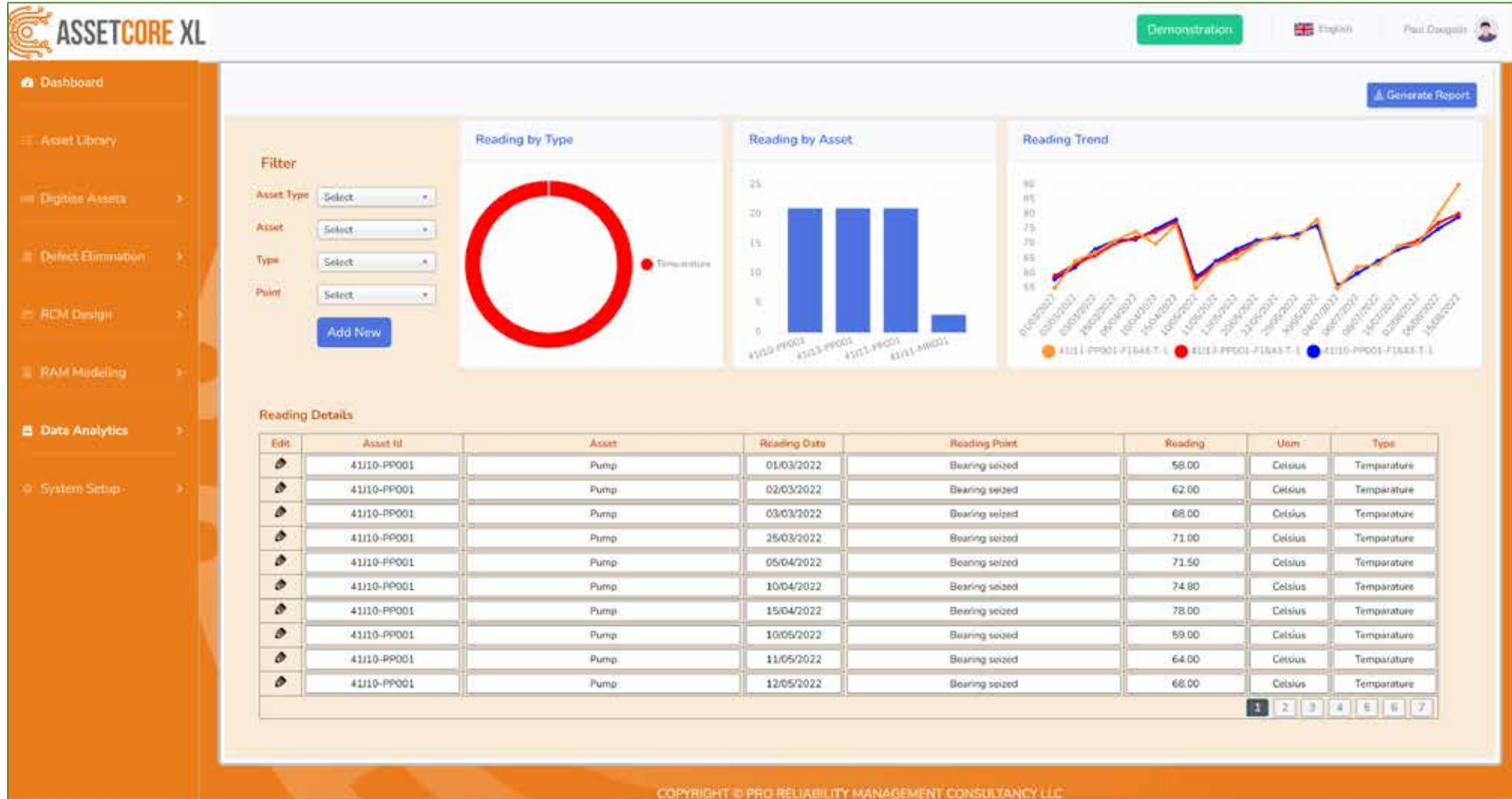
<input type="checkbox"/>	Edit	Id	Description	Asset	Asset Type	Component	Spare Part	Install
<input type="checkbox"/>		80000470	Repair Pinion Lube Sprays	41110-MR001	MOTOR A	Cable, motor	119409-CABLE TRAY,COVER,PEAK,36x1.5M	8/06/20
<input type="checkbox"/>		80000432	Remove Gear Case Covers	41110-MR001	MOTOR A	Motor, induction, small	107197-MOTOR,11KW,1470RPM,160M	22/06/20
<input type="checkbox"/>		80000394	New Scraper Plate Teeth	41110-MR001	MOTOR A	Cable, motor	119409-CABLE TRAY,COVER,PEAK,36x1.5M	13/07/20
<input type="checkbox"/>		80000356	Cracktest Intermediate Gears	41110-MR001	MOTOR A	Rotor, motor	102253-ROTOR,OPEN,ADJUSTABLE,2-12192	29/07/20
<input type="checkbox"/>		80000318	Install P.F. Chute	41110-MR001	MOTOR A	Motor, induction, small	107197-MOTOR,11KW,1470RPM,160M	9/08/20
<input type="checkbox"/>		80000280	Install Roller	41110-MR001	MOTOR A	Bearing, ball	125361-BEARING,ROLLER,22232 CCK/W33	19/08/20
<input type="checkbox"/>		80000280	Install Roller	41110-MR001	MOTOR A	Bearing, ball	109151-BEARING,BALL,3208	19/08/20
<input type="checkbox"/>		80000204	Remove Return Plate	41110-MR001	MOTOR A	Bearing, ball	109151-BEARING,BALL,3208	7/09/20
<input type="checkbox"/>		80000204	Remove Return Plate	41110-MR001	MOTOR A	Bearing, ball	125361-BEARING,ROLLER,22232 CCK/W33	7/09/20
<input type="checkbox"/>		80000166	Install Feed Chute	41110-MR001	MOTOR A	Motor, induction, small	107197-MOTOR,11KW,1470RPM,160M	21/09/20
<input type="checkbox"/>		80000128	Check Lube Sprays	41110-MR001	MOTOR A	Cable, motor	119409-CABLE TRAY,COVER,PEAK,36x1.5M	30/09/20
<input type="checkbox"/>		80000090	Repair Deflector Plate	41110-MR001	MOTOR A	Motor, induction, small	107197-MOTOR,11KW,1470RPM,160M	28/10/20
<input type="checkbox"/>		80000052	Balance Rotor	41110-MR001	MOTOR A	Rotor, motor	102253-ROTOR,OPEN,ADJUSTABLE,2-12192	21/11/20

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Site Data

CONDITION MONITORING DATA





AssetCoreXL Reporting

ONLINE RAM RESULTS

ASSETCORE XL Demonstration English Paul Duggan

Upload file 41-202209.awbx Dataset

Case	Mean Availability (%)	Mean Unavailability (%)	Mean Deliverability (MBSPD)	Mean Target (MBSPD)	Maximum Capacity (MBSPD)	Mean Utilization (%)
Base Case	96.78	3.22	145.18	147.8	150.00	101.9

Production Criticality - Diesel Vacuum Dryer - RTR

Case	Production Loss (%)
J11-D-0001	0.05
J11-D-0004	0.05
J11-D-0003	0.05
J11-E-0005	0.05
J11-G-0005C PH	0.05
J11-G-0003B PH	0.05
J11-G-0005B PH	0.05
J11-G-0004B PH	0.05
J11-G-0002B PH	0.05
J11-E-0001	0.25
J11-E-0002	0.25
J11-E-0004	0.30
J11-K-0002	0.55
J11-K-0001	0.55
7 yearly TSL	0.70

Reliability Losses - Diesel Vacuum Dryer - RTR

Case	No. of outages
J11-D-0001	5
J11-D-0004	5
J11-G-0003B	5
J11-D-0003	5
J11-G-0002B	5
J11-G-0002A	5
J11-G-0003A	5
J11-E-0003	5
J11-K-0002	5
J11-K-0001	5
J11-G-0001C	18
J11-G-0001B	18
J11-G-0001A	18
J11-G-0004A	22
J11-G-0004B	22

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AssetCoreXL Reporting

R&M DATA REPORT
in accordance to SAES-A-0030 Appendix A

PLANT INFORMATION					R&M INFORMATION							R&M DATA INFORMATION							Key Failure Modes and Damage Mechanisms	
Plant ID	Plant Name	Asset ID	Asset Description	Asset Type	Planned Events			Unplanned Events				RBM Data Source	Comments	Failure Mode and/or Damage Mechanism Description	Comments					
					Event Description	Minimum	Most Likely	Maximum	Minimum	Most Likely	Maximum					Failure rate	Minimum	Most Likely	Maximum	
8200	HOPCL UNIT	8200-0-0001	WITHDRAWAL WELD	Weld, surge drum						Abnormal instrument reading	22000		5	ORISA 2011 Technology No. 3.2.10	Restore condition	Abnormal instrument reading				
8200	HOPCL UNIT	8200-0-0002	WITHDRAWAL WELD	Weld, surge drum	Internal inspection		40000		100					SAP-OL paragraph 4.4.	Restore condition	Internal inspection				
8200	HOPCL UNIT	8200-0-0003	WITHDRAWAL WELD	Weld, surge drum						Plugged/Blocked	11170		8	ORISA 2011 Technology No. 3.2.10	Restore condition	Plugged/Blocked				
8200	HOPCL UNIT	8200-0-0004	HOPCL CONDENSATE FLASH DRUM	Weld, flash drum						Abnormal instrument reading	87000		6	ORISA 2011 Technology No. 3.2.8	Restore condition	Abnormal instrument reading				
8200	HOPCL UNIT	8200-0-0005	HOPCL CONDENSATE FLASH DRUM	Weld, flash drum	Internal inspection		40000		100					SAP-OL paragraph 4.4.	Restore condition	Internal inspection				
8200	HOPCL UNIT	8200-0-0006	HOPCL CONDENSATE FLASH DRUM	Weld, flash drum						Excessive deviation	84000		3	ORISA 2011 Technology No. 3.2.8	Restore condition	Excessive deviation				
8200	HOPCL UNIT	8200-0-0007	LP CONDENSATE FLASH DRUM	Weld, flash drum						Abnormal instrument reading	91000		9	ORISA 2011 Technology No. 3.2.8	Restore condition	Abnormal instrument reading				
8200	HOPCL UNIT	8200-0-0008	LP CONDENSATE FLASH DRUM	Weld, flash drum	Internal inspection		40000		100					SAP-OL paragraph 4.4.	Restore condition	Internal inspection				
8200	HOPCL UNIT	8200-0-0009	LP CONDENSATE FLASH DRUM	Weld, flash drum						Excessive deviation	78000		2	ORISA 2011 Technology No. 3.2.8	Restore condition	Excessive deviation				
8200	HOPCL UNIT	8200-0-0010	CONDENSATE BLOWDOWN SYSTEM	Weld, surge drum						Abnormal instrument reading	22000		3	ORISA 2011 Technology No. 3.2.10	Restore condition	Abnormal instrument reading				
8200	HOPCL UNIT	8200-0-0011	CONDENSATE BLOWDOWN SYSTEM	Weld, surge drum	Internal inspection		40000		100					SAP-OL paragraph 4.4.	Restore condition	Internal inspection				
8200	HOPCL UNIT	8200-0-0012	CONDENSATE BLOWDOWN SYSTEM	Weld, surge drum						Plugged/Blocked	11170		8	ORISA 2011 Technology No. 3.2.10	Restore condition	Plugged/Blocked				
8200	HOPCL UNIT	8200-0-0013	INTERMEDIATE BLOWDOWN SYSTEM	Weld, surge drum						Abnormal instrument reading	22000		3	ORISA 2011 Technology No. 3.2.10	Restore condition	Abnormal instrument reading				
8200	HOPCL UNIT	8200-0-0014	INTERMEDIATE BLOWDOWN SYSTEM	Weld, surge drum	Internal inspection		40000		100					SAP-OL paragraph 4.4.	Restore condition	Internal inspection				
8200	HOPCL UNIT	8200-0-0015	INTERMEDIATE BLOWDOWN SYSTEM	Weld, surge drum						Plugged/Blocked	11170		8	ORISA 2011 Technology No. 3.2.10	Restore condition	Plugged/Blocked				
8200	HOPCL UNIT	8200-0-0016	WATER AIR SEPARATORS SURFACE EXCHANGER	Exchanger, hot tank						External leakage - Process medium	20000		8	ORISA 2011 Technology No. 3.1.2	Restore condition	External leakage - Process medium				
8200	HOPCL UNIT	8200-0-0017	WATER AIR SEPARATORS SURFACE EXCHANGER	Exchanger, hot tank						Insufficient heat transfer	14000		6	ORISA 2011 Technology No. 3.1.2	Restore condition	Insufficient heat transfer				
8200	HOPCL UNIT	8200-0-0018	WATER AIR SEPARATORS SURFACE EXCHANGER	Exchanger, hot tank	Internal inspection		40000		80					SAP-OL - Air cooled Heat Exchangers Reliability & Maintenance Guidelines	Restore condition	Internal inspection	Safe, positive, isolation			
8200	HOPCL UNIT	8200-0-0019	WATER AIR SEPARATORS SURFACE EXCHANGER	Exchanger, hot tank						Minor process problems	20000		2	ORISA 2011 Technology No. 3.1.2	Restore condition	Minor process problems				
8200	HOPCL UNIT	8200-0-0020	REGENERATOR FLUE GAS COOLER	Exchanger, hot and cold						Abnormal instrument reading	80000		8.0	ORISA 2011 Technology No. 3.1.3	Restore condition	Abnormal instrument reading				
8200	HOPCL UNIT	8200-0-0021	REGENERATOR FLUE GAS COOLER	Exchanger, hot and cold						External leakage - Process medium	32000		10	ORISA 2011 Technology No. 3.1.3	Restore condition	External leakage - Process medium				
8200	HOPCL UNIT	8200-0-0022	REGENERATOR FLUE GAS COOLER	Exchanger, hot and cold	Internal inspection		40000		100					SAP-OL paragraph 4.4.	Restore condition	Internal inspection				
8200	HOPCL UNIT	8200-0-0023	REGENERATOR FLUE GAS COOLER	Exchanger, hot and cold						Excessive deviation	20000		10	ORISA 2011 Technology No. 3.1.3	Restore condition	Excessive deviation				
8200	HOPCL UNIT	8200-0-0024	REGENERATOR FLUE GAS COOLER	Exchanger, hot and cold						Plugged/Blocked	50000		10	ORISA 2011 Technology No. 3.1.3	Restore condition	Plugged/Blocked				



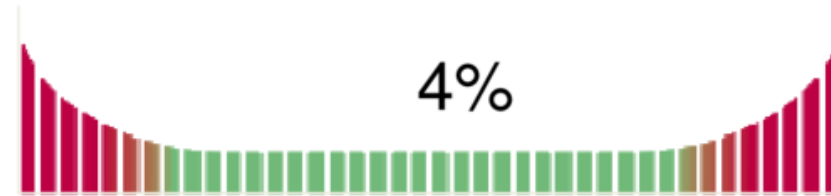
Evaluate RCM Decisions Against Production Targets



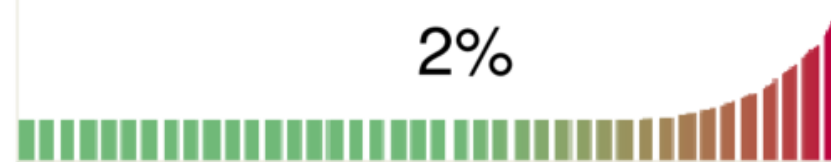


RCM Principles

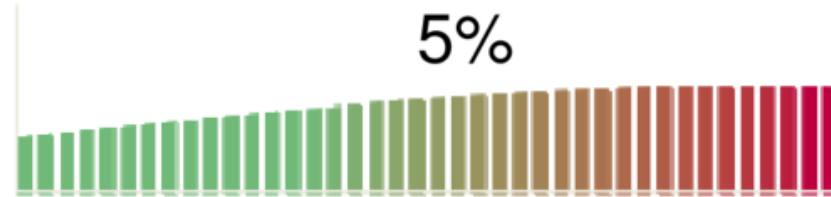
<20% age related



A - Bathtub

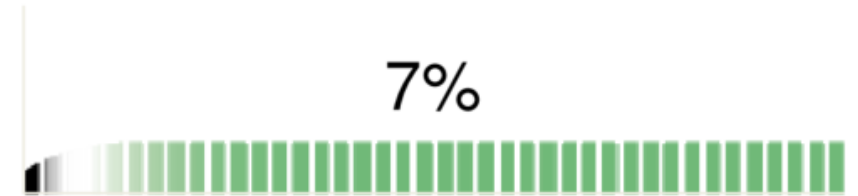


B - Random, ending with wear out zone

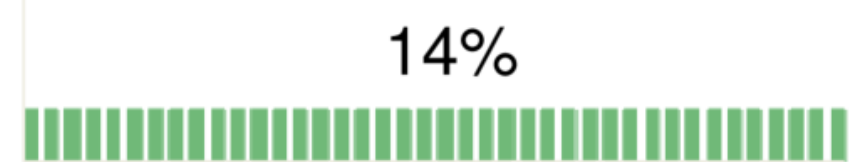


C - Slowly increasing to random

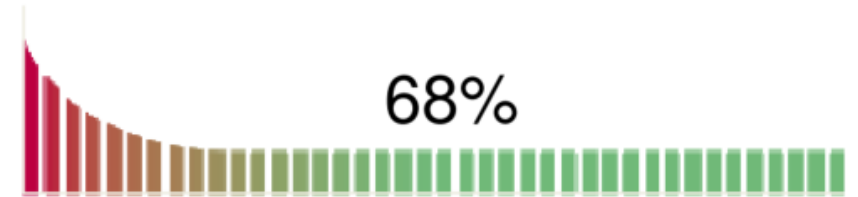
>80% random



D - Rapid increase to random



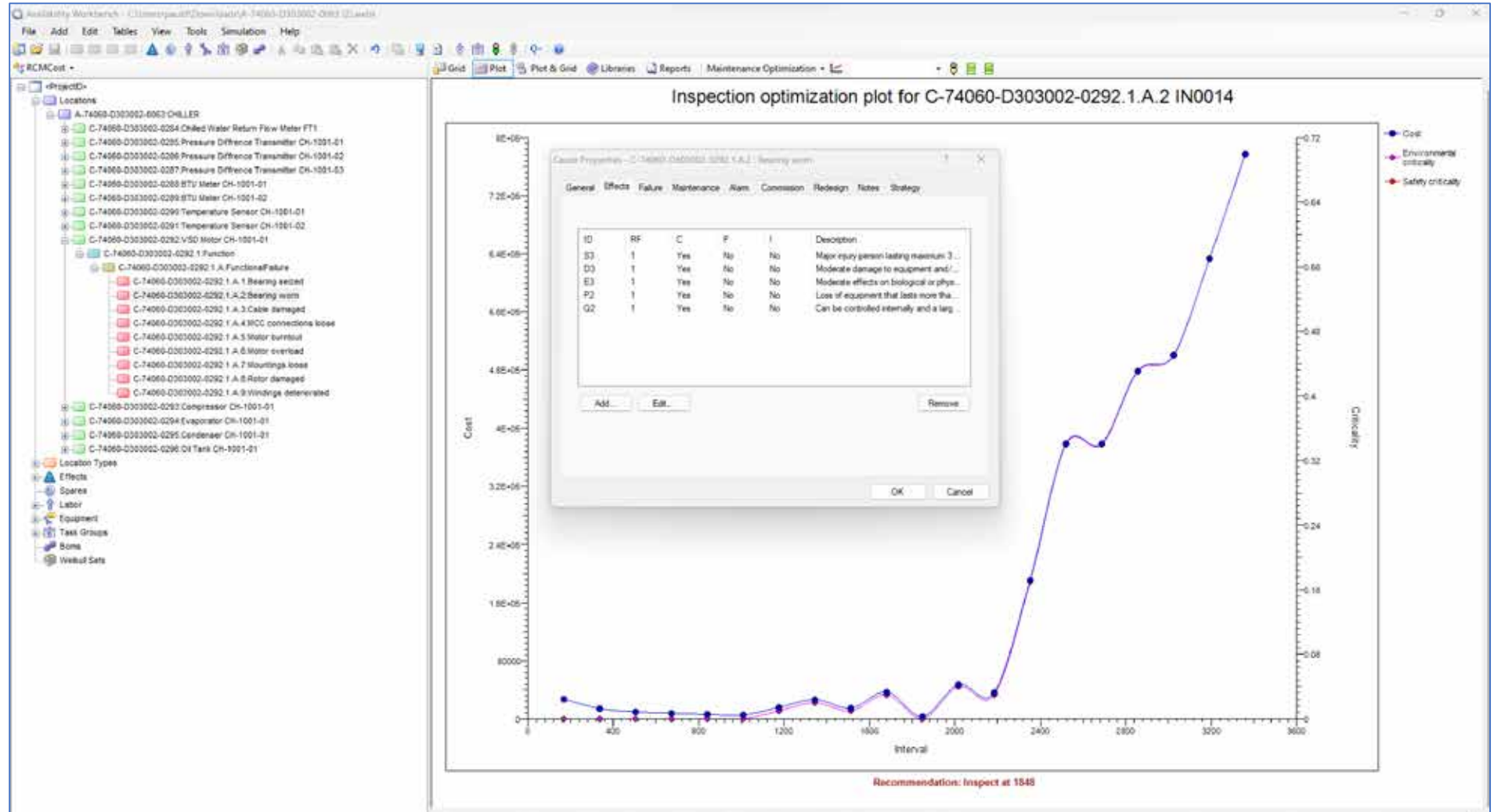
E - Random Failure



F - Infant mortality, decreasing to random



RCM Principles



Site Data

Failure mode:

CASING-BOTTOM
TWISTED CAUSED BY
DESIGN_INCORRECT

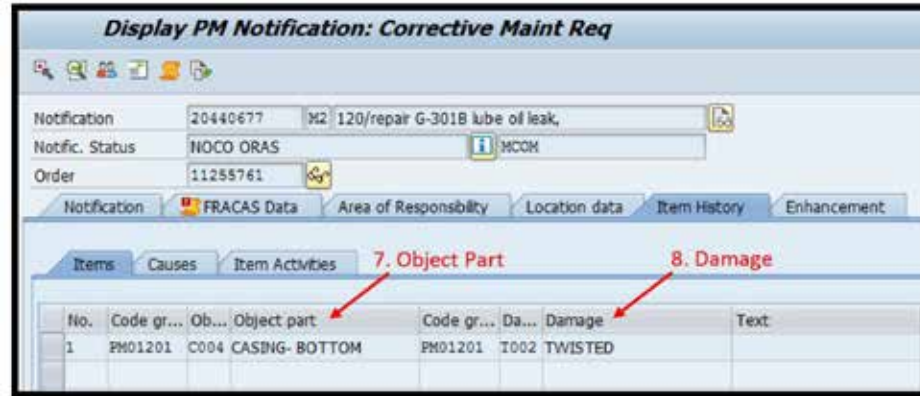


Figure [1-B] – Fields Evaluated in SAP

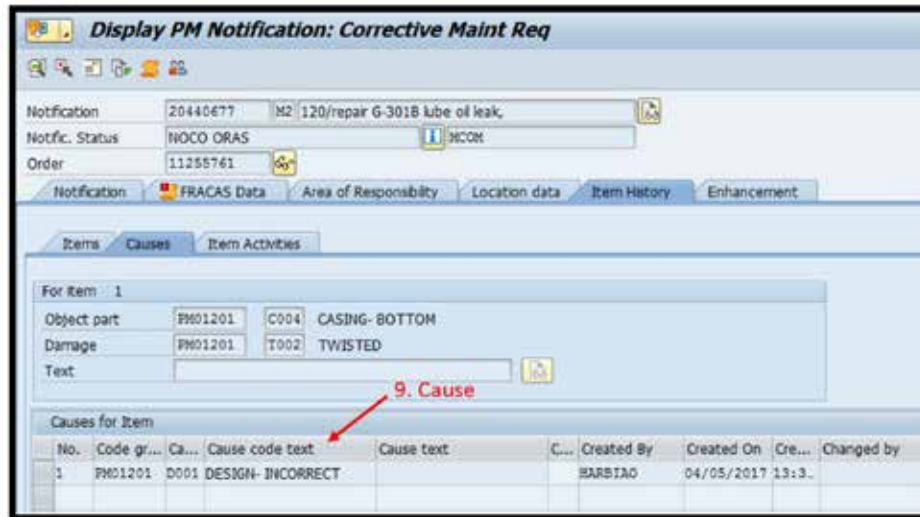
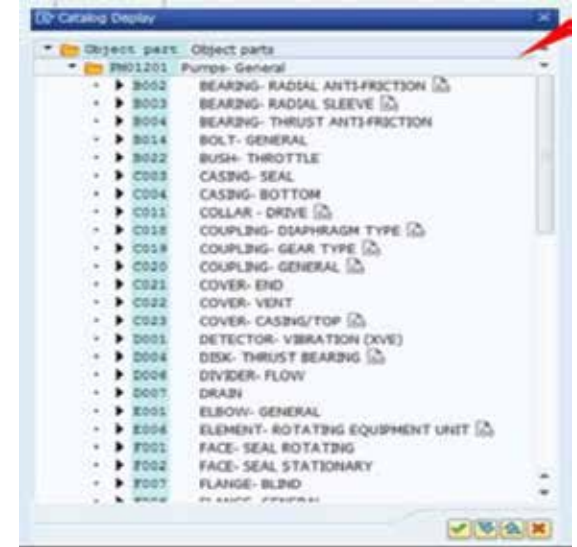
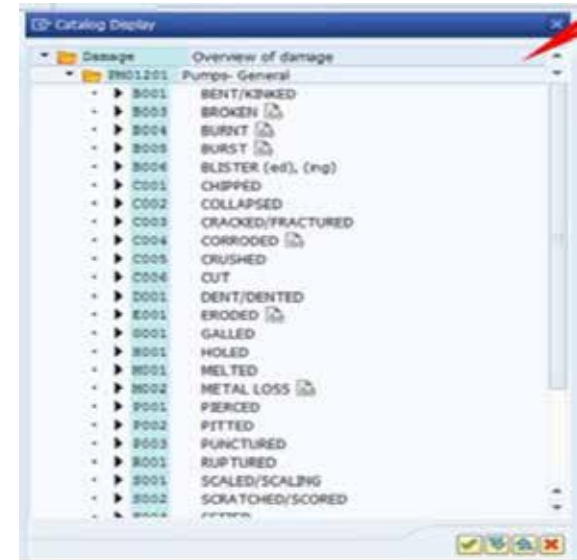
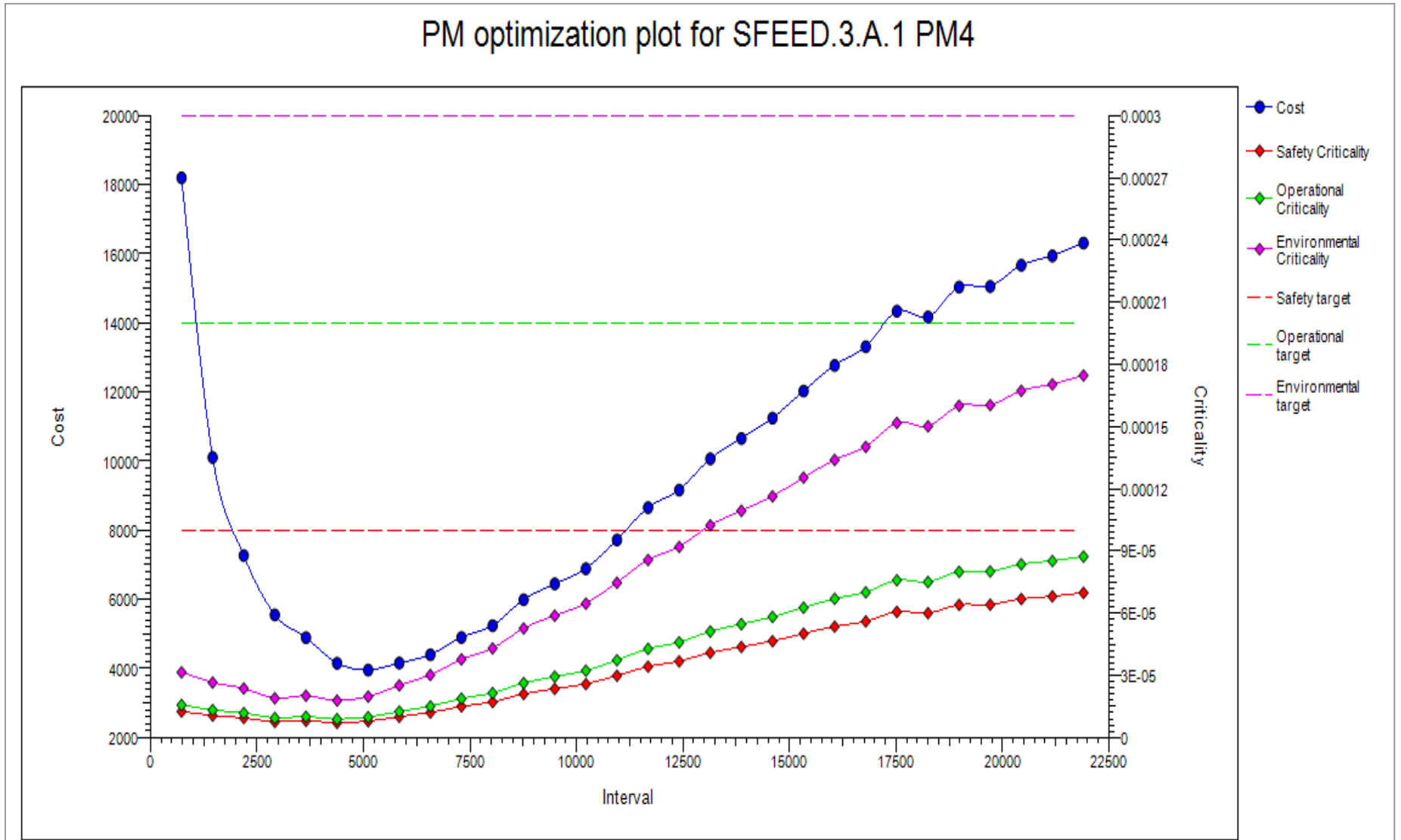


Figure [1-C] – Fields Evaluated in SAP



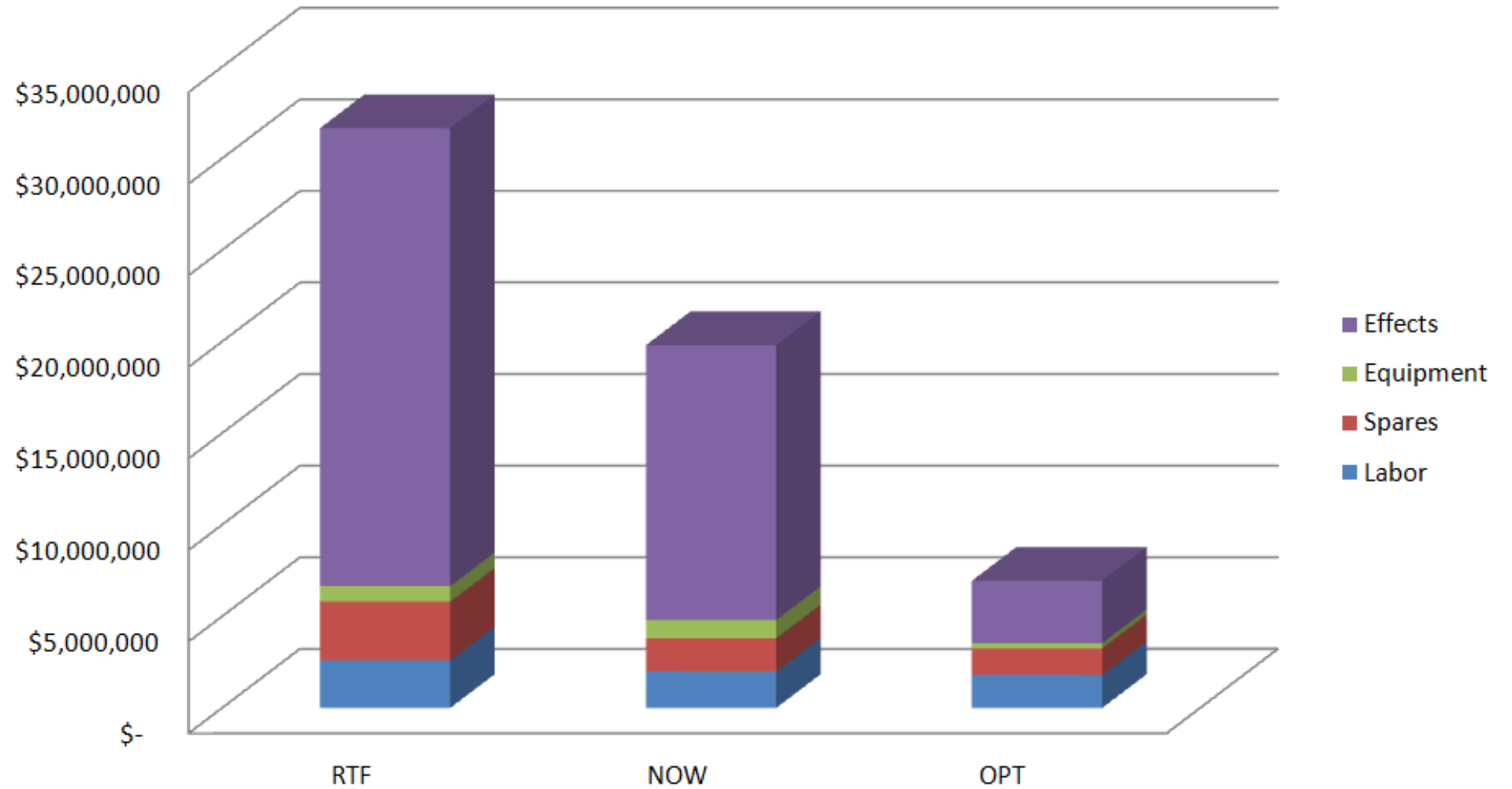
Optimisation

PM optimization plot for SFEED.3.A.1 PM4





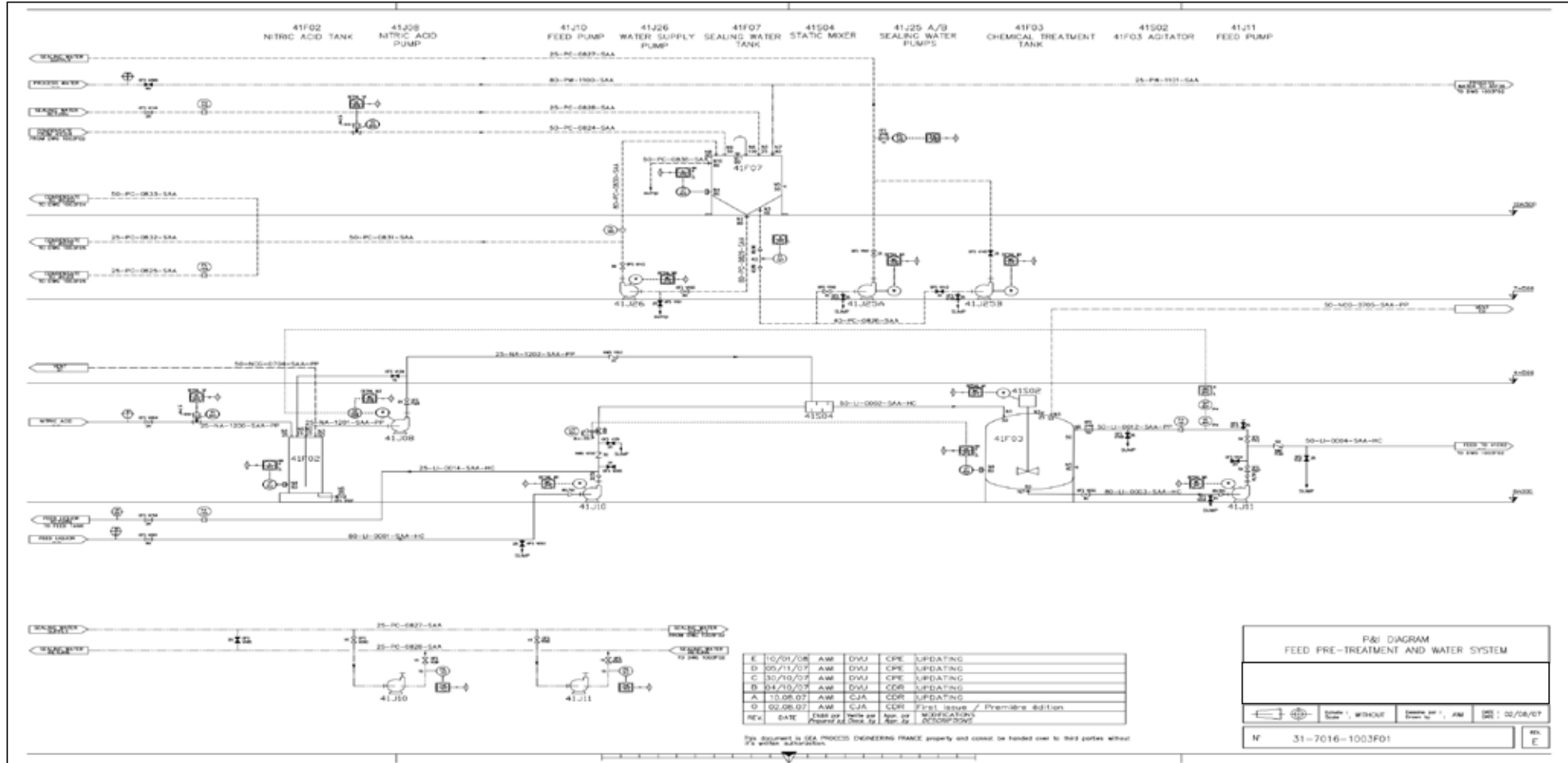
Sensitivity Cases



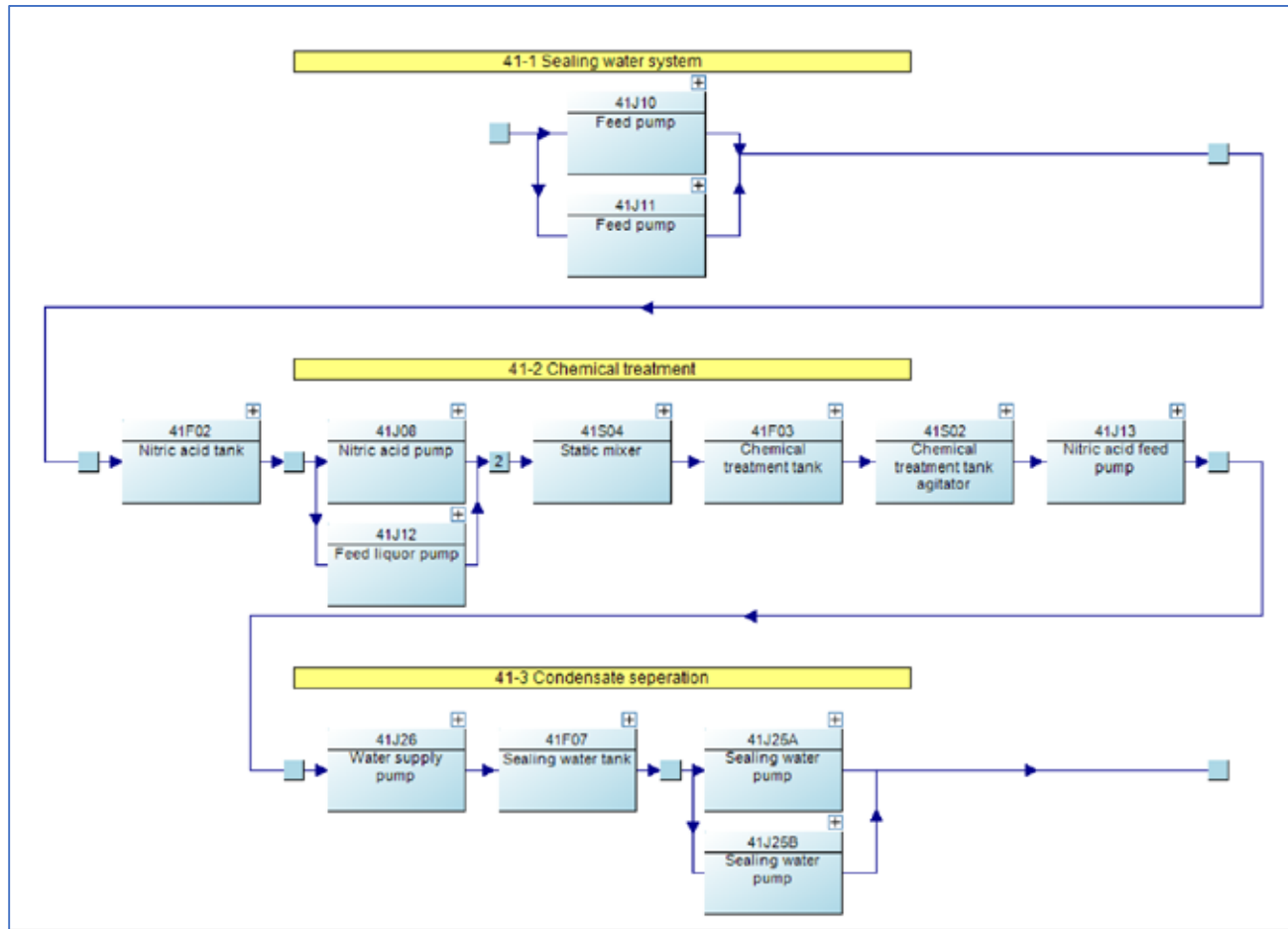


Sensitivity Cases

FEED PRE-TREATMENT & WATER SYSTEM



Sensitivity Cases



Failure Model Properties - 41J25A-PP001.1A.101 Mounting degradation

General Failure Maintenance Alarm Corrosion Redesign Notes Strategy

- Corrective
 - CM0257 Repair mountings
- Planned
 - PM0338 (Disabled) Repair mountings
- Inspection
 - IN0313 Inspect footings, mountings for wear, corrosion & damage

New... Edit... Remove

Copy Task From Library... Use current project Use task group hierarchy

Task library:

OK Cancel

Simulation Results

Life Costs Systems Components Consequences Labor

ID	Description
41	Feed pre-treatment and water system
41-1	Sealing water system
41J10	Feed pump
41J10-FSL112	Flow Switch Low
41J10-MC001	Motor control centre

ID: 41

- Total down time: 6902
- Std total down time: 1114
- Error % total down time: 5.102
- Treated water flow capacity: 92.12 m³/hr
- Treated water std capacity: 1.271 m³/hr
- Treated water flow % capacity: 0.4364
- Mean unavailability: 0.07679
- Unavailability at lifetime: 0
- No of outages: 403.3
- Std no of outages: 7.747
- Error % no of outages: 0.6074
- F: 1
- Time in standby: 0
- MTTD: 490.5
- MTBO: 217.2
- MTTR: 17.11

* To obtain accurate MTTD, MTBO and MTTR values set project lifetime >> MTBO

Close



Sensitivity Cases

CURRENT AND OPTIMISED MAINTENANCE STRATEGIES

Asset	Task	Interval	Duration	Trade
41F02-TK001	Check the integrity of any earth or ground system cabling	8760	0.1	MEC(1)
41F02-TK001	Check condition of any manholes and clean out doors.	8760	0.2	MEC(1)
41F02-TK001	Visual inspection of the tank and shell of any distortion	8760	0.2	MEC(1)
41F02-TK001	Inspect handrails & ladders for excessive corrosion, looseness or damage.	8760	0.2	MEC(1)
41F02-TK001	Inspect handrails & ladders for excessive corrosion, looseness or damage.	8760	0.2	MEC(1)
41F02-TK001	Inspect tank flanges and fittings for leaks	8760	0.2	MEC(1)
41F02-TK001	Inspect flanges and fittings for leaks	8760	0.2	MEC(1)
41F02-TK001	Check operation and for clear passage of any breathers or vents on the tank.	8760	0.2	MEC(1)
41F03-TK001	Check the integrity of any earth or ground system cabling	8760	0.1	MEC(1)
41F03-TK001	Check condition of any manholes and clean out doors.	8760	0.2	MEC(1)
41F03-TK001	Visual inspection of the tank and shell of any distortion	8760	0.2	MEC(1)
41F03-TK001	Inspect handrails & ladders for excessive corrosion, looseness or damage.	8760	0.2	MEC(1)
41F03-TK001	Inspect handrails & ladders for excessive corrosion, looseness or damage.	8760	0.2	MEC(1)
41F03-TK001	Inspect tank flanges and fittings for leaks	8760	0.2	MEC(1)
41F03-TK001	Inspect flanges and fittings for leaks	8760	0.2	MEC(1)
41F03-TK001	Check operation and for clear passage of any breathers or vents on the tank.	8760	0.2	MEC(1)
41F07-PP001	Inspect footings, mountings for wear, corrosion & damage.	8760	0.1	MEC(1)
41F07-TK001	Inspect support structure for damage and corrosion including foundation bolts	8760	0.2	MEC(1)
41F07-TK001	Inspect condition of insulation on tank	8760	0.25	MEC(1)
41F07-TK001	Check the integrity of any earth or ground system cabling	8760	0.1	MEC(1)
41F07-TK001	Check condition of any manholes and clean out doors.	8760	0.2	MEC(1)
41F07-TK001	Visual inspection of the tank and shell of any distortion	8760	0.2	MEC(1)
41F07-TK001	Inspect handrails & ladders for excessive corrosion, looseness or damage.	8760	0.2	MEC(1)
41F07-TK001	Inspect tank flanges and fittings for leaks	8760	0.2	MEC(1)
41F07-TK001	Inspect flanges and fittings for leaks	8760	0.2	MEC(1)
41F07-TK001	Check operation and for clear passage of any breathers or vents on the tank.	8760	0.2	MEC(1)
41J08-PP001	Inspect footings, mountings for wear, corrosion & damage.	8760	0.1	MEC(1)
41J10-FSL112	Inspect flanges and fittings for leaks	8760	0.2	MEC(1)
41J10-PP001	Inspect footings, mountings for wear, corrosion & damage.	8760	0.1	MEC(1)
41J11-FSL113	Inspect flanges and fittings for leaks	8760	0.2	MEC(1)
41J11-PP001	Inspect footings, mountings for wear, corrosion & damage.	8760	0.1	MEC(1)
41J12-PP001	Inspect footings, mountings for wear, corrosion & damage.	8760	0.1	MEC(1)
41J13-PP001	Inspect footings, mountings for wear, corrosion & damage.	8760	0.1	MEC(1)
41J26-PP001	Inspect footings, mountings for wear, corrosion & damage.	8760	0.1	MEC(1)
41S03-AG001	Visual inspection of impeller for wear, looseness & damage.	8760	1	MEC(1)
41S03-AG001	Inspect shaft for eccentricity.	8760	0.5	MEC(1)
41S03-AG001	Inspect footings, mountings for wear, corrosion & damage.	8760	0.1	MEC(1)
41S04-MX001	Visual inspection of impeller for wear, looseness & damage.	8760	1	MEC(1)
41S04-MX001	Inspect shaft for eccentricity.	8760	0.5	MEC(1)
41S04-MX001	Inspect footings, mountings for wear, corrosion & damage.	8760	0.1	MEC(1)



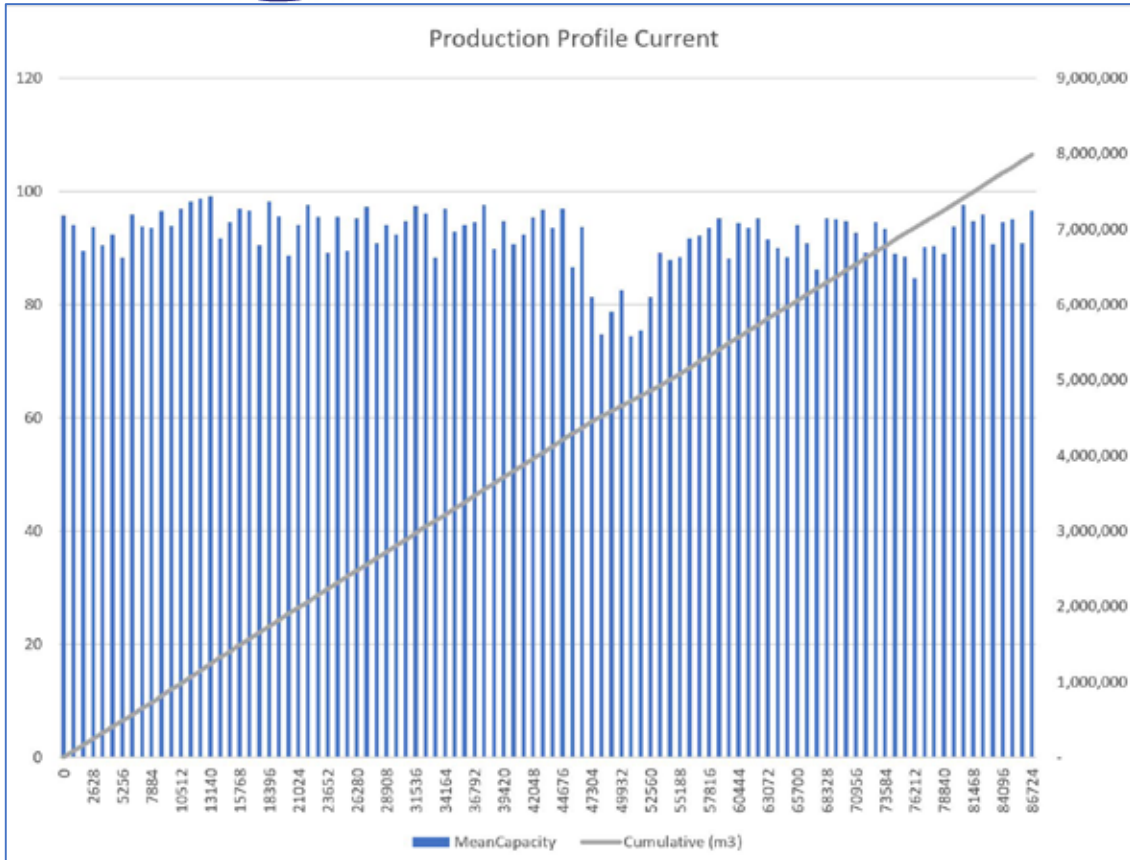
Asset	Task	Interval	Duration	Trade
41F02-TK001	Check the integrity of any earth or ground system cabling	8760	0.1	MEC(1)
41F02-TK001	Check condition of any manholes and clean out doors.	17520	0.2	MEC(1)
41F02-TK001	Visual inspection of the tank and shell of any distortion	8760	0.2	MEC(1)
41F02-TK001	Inspect handrails & ladders for excessive corrosion, looseness or damage.	8760	0.2	MEC(1)
41F02-TK001	Inspect handrails & ladders for excessive corrosion, looseness or damage.	8760	0.2	MEC(1)
41F02-TK001	Inspect tank flanges and fittings for leaks	8760	0.2	MEC(1)
41F02-TK001	Inspect flanges and fittings for leaks	8760	0.2	MEC(1)
41F02-TK001	Check operation and for clear passage of any breathers or vents on the tank.	8760	0.2	MEC(1)
41F03-TK001	Check the integrity of any earth or ground system cabling	8760	0.1	MEC(1)
41F03-TK001	Check condition of any manholes and clean out doors.	17520	0.2	MEC(1)
41F03-TK001	Visual inspection of the tank and shell of any distortion	8760	0.2	MEC(1)
41F03-TK001	Inspect handrails & ladders for excessive corrosion, looseness or damage.	8760	0.2	MEC(1)
41F03-TK001	Inspect handrails & ladders for excessive corrosion, looseness or damage.	8760	0.2	MEC(1)
41F03-TK001	Inspect tank flanges and fittings for leaks	8760	0.2	MEC(1)
41F03-TK001	Inspect flanges and fittings for leaks	8760	0.2	MEC(1)
41F03-TK001	Check operation and for clear passage of any breathers or vents on the tank.	8760	0.2	MEC(1)
41F07-PP001	Inspect footings, mountings for wear, corrosion & damage.	8760	0.1	MEC(1)
41F07-TK001	Inspect support structure for damage and corrosion including foundation bolts	8760	0.2	MEC(1)
41F07-TK001	Inspect condition of insulation on tank	43800	0.25	MEC(1)
41F07-TK001	Check the integrity of any earth or ground system cabling	8760	0.1	MEC(1)
41F07-TK001	Check condition of any manholes and clean out doors.	17520	0.2	MEC(1)
41F07-TK001	Visual inspection of the tank and shell of any distortion	8760	0.2	MEC(1)
41F07-TK001	Inspect handrails & ladders for excessive corrosion, looseness or damage.	8760	0.2	MEC(1)
41F07-TK001	Inspect tank flanges and fittings for leaks	8760	0.2	MEC(1)
41F07-TK001	Inspect flanges and fittings for leaks	8760	0.2	MEC(1)
41F07-TK001	Check operation and for clear passage of any breathers or vents on the tank.	8760	0.2	MEC(1)
41J08-PP001	Inspect footings, mountings for wear, corrosion & damage.	17520	0.1	MEC(1)
41J10-FSL112	Inspect flanges and fittings for leaks	8760	0.2	MEC(1)
41J10-PP001	Inspect footings, mountings for wear, corrosion & damage.	17520	0.1	MEC(1)
41J11-FSL113	Inspect flanges and fittings for leaks	17520	0.2	MEC(1)
41J11-PP001	Inspect footings, mountings for wear, corrosion & damage.	17520	0.1	MEC(1)
41J12-PP001	Inspect footings, mountings for wear, corrosion & damage.	17520	0.1	MEC(1)
41J13-PP001	Inspect footings, mountings for wear, corrosion & damage.	17520	0.1	MEC(1)
41J26-PP001	Inspect footings, mountings for wear, corrosion & damage.	17520	0.1	MEC(1)
41S03-AG001	Visual inspection of impeller for wear, looseness & damage.	43800	1	MEC(1)
41S03-AG001	Inspect shaft for eccentricity.	17520	0.5	MEC(1)
41S03-AG001	Inspect footings, mountings for wear, corrosion & damage.	17520	0.1	MEC(1)
41S04-MX001	Visual inspection of impeller for wear, looseness & damage.	43800	1	MEC(1)
41S04-MX001	Inspect shaft for eccentricity.	17520	0.5	MEC(1)
41S04-MX001	Inspect footings, mountings for wear, corrosion & damage.	17520	0.1	MEC(1)

ME1Y ANNUAL MECHANICAL PREVENTIVE MAINTENANCE (CURRENT)

AFTER OPTIMISATION

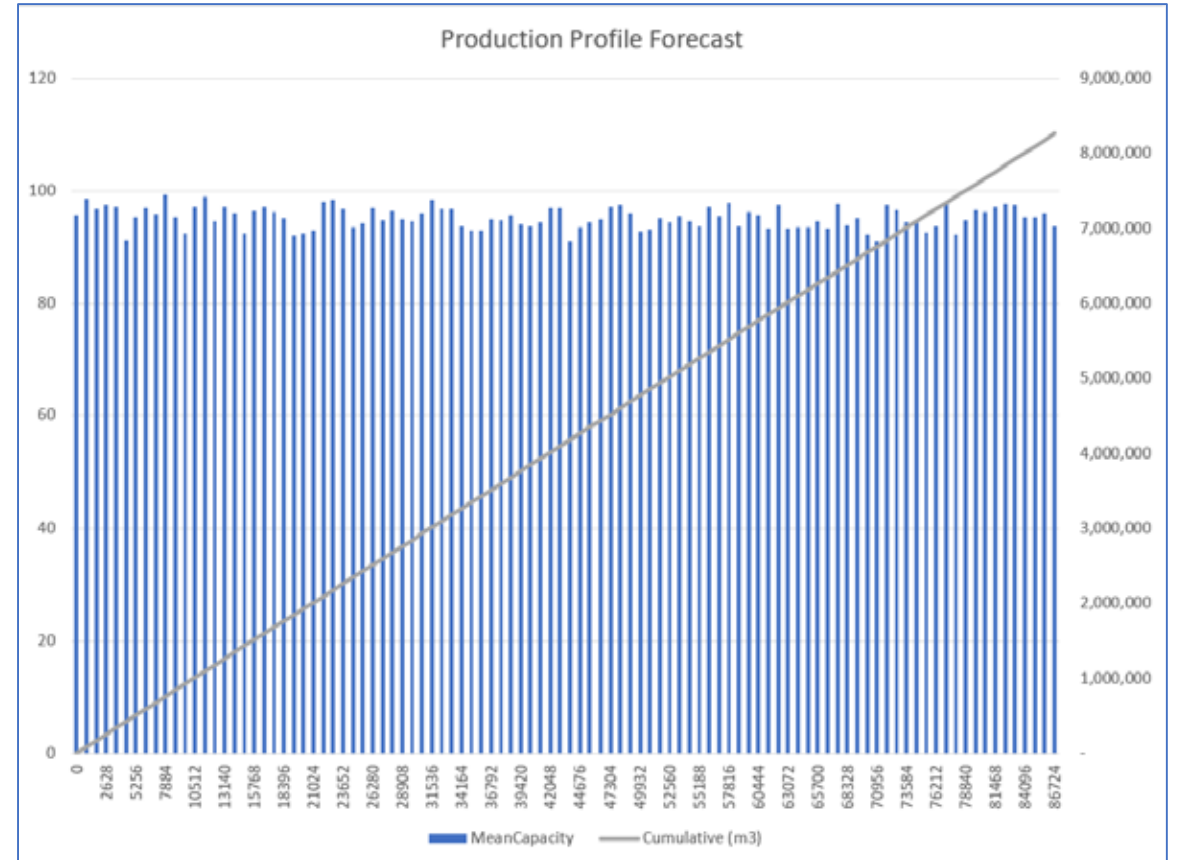


Sensitivity Cases



7,985,103 m³
TOTAL m³ (CURRENT)

f X in + #OmaintecConf



8,265,061 m³
TOTAL m³ (FORECAST)

3.51% ↑
279,958 m³
ADDITIONAL PRODUCT

RBD with strategy 1 and 2 with system profile in production units m3/hr



Maintenance Budgeting & NPV Calculations Over Asset Life





Maintenance Budget

- **Total labor costs**

- Total corrective labor costs
- Total planned labor costs
- Total inspection labor costs

- **Total equipment costs**

- Total corrective equipment costs
- Total planned equipment costs
- Total inspection equipment costs
- Total spare purchase costs
- Corrective spare purchase costs
- Planned spare purchase costs

- **Spare storage costs**

- **Total effect costs**

- Corrective effect costs
- Planned effect costs
- Inspection effect costs

- **Alarm costs**

- **Total operational costs**

- Corrective operational costs
- Planned operational costs
- Inspection operational costs

- **Commission costs**

- **Redesign costs**

- **Total costs**

- Safety criticality
- Operational criticality
- Environmental criticality
- Spares volume level 1
- Spares volume level 2
- Spares weight level 1
- Spares weight level 2



Maintenance Budget

Labor Properties - MECH : Mechanical Fitter

General Notes

ID: MECH

Type: Not set

Description: Mechanical Fitter

Number available: 1000 Cost rate: 25

Corrective logistic delay: 1

Corrective call-out cost: 50

Scheduled call-out cost: 0

OK

LABOR SETUP

Equipment Properties - Equipment1

General Notes

ID: C1

Type: Not set

Description: Small crane

Number available: 12 Cost rate: 150

Corrective logistic delay: 1

Corrective call-out cost: 200

Scheduled call-out cost: 0

OK Cancel

EQUIPMENT SETUP

Spare Properties - M6 : Compressor motor

General Level 1 Level 2 Level 3 Repair Shop Notes Optimization

ID: M6

Type: Not set

Description: Compressor motor

Unit cost: 65000

Unit volume: 1.25 m3

Unit weight: 250 kg

OK Cancel

SPARE SETUP



Maintenance Budget

Cause Properties - AS.1.A.1 : Worn bearings

General Effects Failure Maintenance Alarm Commission Redesign Notes Strategy

- Corrective
 - CM7: Replace bearings
- Planned
 - PM7: Overhaul pump
- Inspection
 - IN7 [Disabled]: Perform vibration monitoring survey

New... Edit... Remove

Copy Task From Library... Use current project Use task group hierarchy

Task library:

OK Cancel

Task Properties - CM7 : Replace bearings

General Advanced Notes

Description: Replace bearings

Task ID: CM7

Task duration: 4 Operational cost: 500

Ramp time: 0.5

Resources:

- F2 x 1 Fitter - General
- C1 x 1 Small crane
- BB-3XY8395A x 14 Ball bearings
- DSA-1709645 x 1 Drive shaft assembly

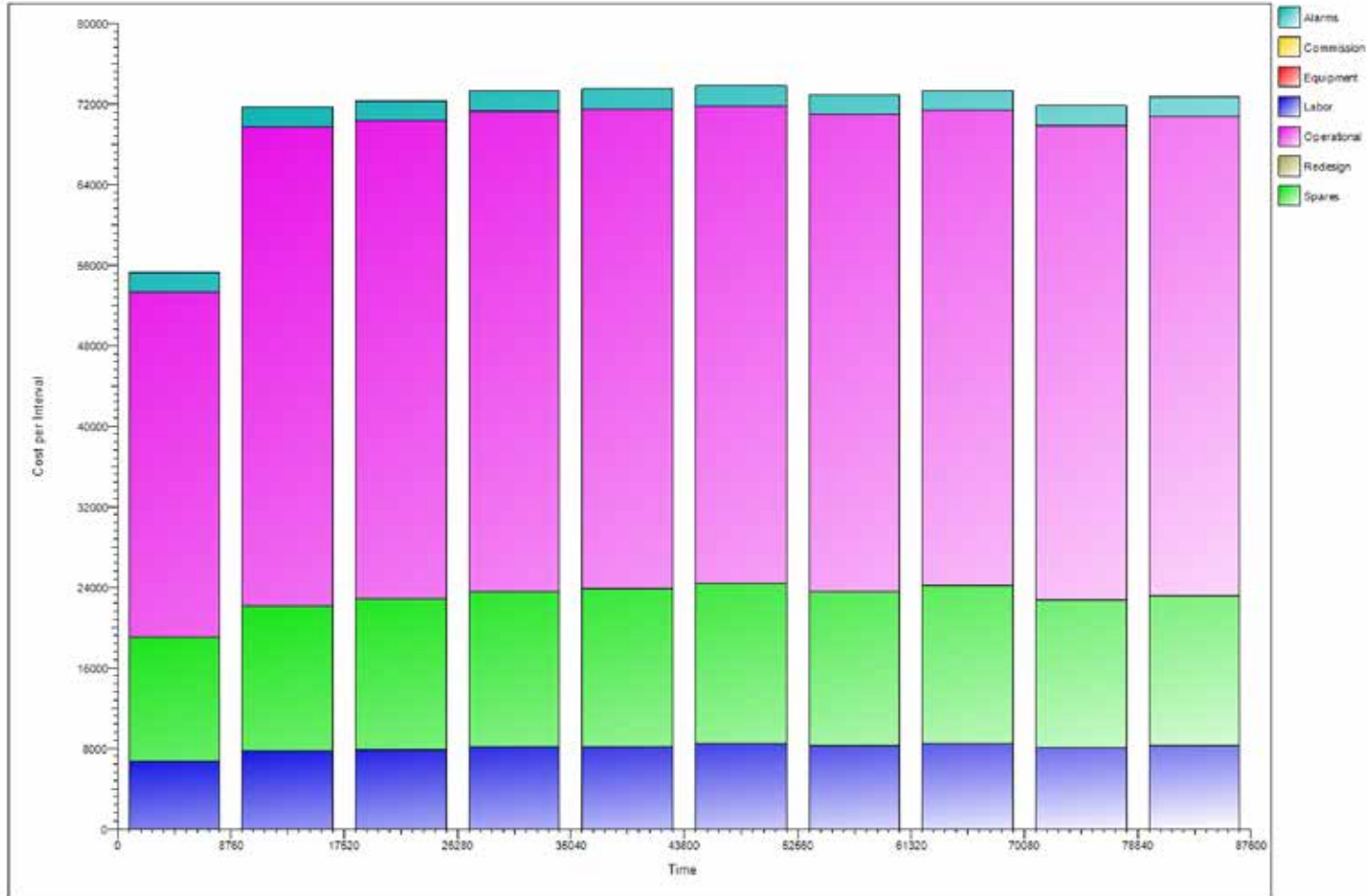
Add... Add... Add... Edit... Remove

OK Cancel



Maintenance Budget

Cost Profile



Simulation Results

Life Costs Causes Effects Spares Labor

Detailed life costs

Lifetime: 87600
 No RCM simulations: 200

Total corrective labor costs: 36408.5144
 Total planned labor costs: 43779.966
 Total inspection labor costs: 0
 Total corrective equipment costs: 0
 Total planned equipment costs: 0
 Total inspection equipment costs: 0
 Corrective spare purchase costs: 100889.9
 Planned spare purchase costs: 48325.6
 Spare storage costs: 0
 Corrective effect costs: 29119210.2
 Planned effect costs: 0
 Inspection effect costs: 0
 Alarm costs: 20000
 Corrective operational costs: 0
 Planned operational costs: 461286
 Inspection operational costs: 0
 Commission costs: 0
 Redesign costs: 0

Total costs: 29829900.2

Safety criticality: 0.00371575628
 Operational criticality: 0.000678268836
 Environmental criticality: 0.000243207763
 Spares volume level 1: 0
 Spares volume level 2: 0
 Spares weight level 1: 0
 Spares weight level 2: 0

Close



Net Present Value

•**Net Present Value (NPV):** This is a way to figure out how much money an investment is worth to you today when you consider the money you'll get from it in the future. Think of it as a tool that helps you decide whether a future stream of money (like profits from a business) is a good deal based on its value in today's dollars.

•**Yield:** This often refers to the return or profit you get from an investment. Also known as The "NPV yield % per interval" or Internal Rate of Return (IRR) would then be like asking: "Considering what all my future earnings are worth in today's dollars, what's my average profit each year?"

•**Interval:** This is a specific length of time (like a year, a month, etc.).

$$\sum_{i=1}^n \frac{CF_i}{(1+r)^i}$$

n = total number of periods (in the table above this would be 5)

i = period, where period starts at value 1

CF = CashFlow at end of period

r = rate of return





Net Present Value

1. Power Stations:

- i. Fossil Fuel Power Plants (coal, gas, etc.): 8% to 15%
- ii. Renewable Energy Plants (solar, wind): 5% to 12%

2. Oil & Gas:

- i. Exploration & Production: 10% to 20%
- ii. Refining & Marketing: 6% to 12%
- iii. Pipelines & Distribution: 5% to 10%

3. Mining:

- i. Precious Metals (Gold, Silver): 5% to 12%
- ii. Base Metals (Copper, Zinc): 8% to 15%
- iii. Bulk Commodities (Iron, Coal): 10% to 20%

4. Manufacturing:

- i. Heavy Machinery: 8% to 12%
- ii. Consumer Goods: 5% to 10%
- iii. High-tech/Electronics: 10% to 20%

5. Rail:

- i. Freight Railways: 7% to 12%
- ii. Passenger Railways: Often lower, sometimes even negative without government subsidies, especially for urban networks.

6. Water Utilities:

- i. 5% to 9%

7. Sewage Utilities:

- i. 5% to 9%



Net Present Value

1. Labor Escalation %: Labor costs typically escalate with inflation and can range from 2% to 7% per annum, depending on the region, industry, and specific labor market conditions.

2. Equipment Escalation %: Equipment costs can vary widely based on technological changes, demand, and supply factors. A general range might be 1% to 5% per annum, with certain industries or technologies seeing occasional spikes due to breakthroughs or supply chain disruptions.

3. Spare Purchase and Repair Escalation %: This would be in line with equipment escalation, so around 1% to 5%, but could be higher if there's a sudden demand or a change in technology.

4. Spare Storage Escalation %: The costs associated with storage, which might include warehousing and inventory management, could escalate around 2% to 6% annually.

5. Operational Escalation %: Operational costs typically increase with inflation and additional regulatory or maintenance requirements. This might range between 2% and 7%.

6. Outage Escalation %: This would be industry-specific and harder to generalize. Outages, especially unplanned ones, can be costly, and the cost impact can vary year by year.

7. Alarm Escalation %: This refers to the costs related to monitoring and alarm systems. With technological advancements, these costs could decrease in some years, but on average might escalate around 1% to 4%.

8. Commissioning Escalation %: The costs associated with commissioning new equipment or facilities might rise at around 2% to 6% annually, depending on the industry and region.

9. Redesign Escalation %: Redesign or retrofitting costs can vary widely based on industry and specific needs. On average, you might see an escalation of 3% to 8%, especially if significant changes or upgrades are needed.



Net Present Value

Project Options

General Lifetime Simulation Products **NPV** Spares Importance Capacity Availability

Apply NPV and escalation calculations to simulated life costs

NPV yield % per interval: 8%

Escalation % per interval

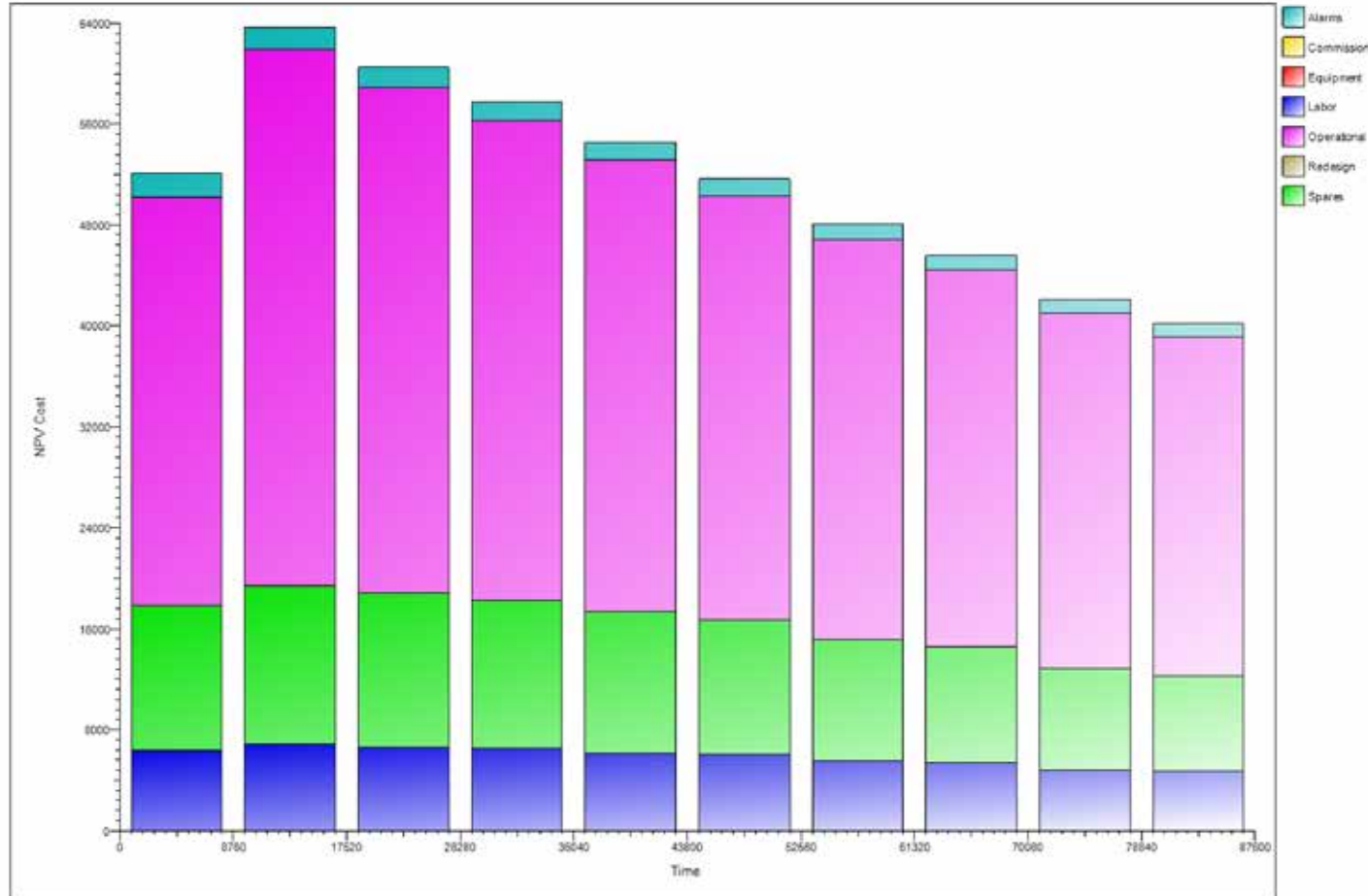
Labor escalation %:	2
Equipment escalation %:	1
Spare purchase and repair escalation %:	1
Spare storage escalation %:	2
Operational escalation %:	2
Outage escalation %:	0
Alarm escalation %:	1
Commissioning escalation %:	2
Redesign escalation %:	3

OK Cancel



Net Present Value

Cost Profile



Simulation Results

Life Costs Causes Effects Spares Labor

Detailed life costs

```

Lifetime: 87600
No RCM simulations: 200
NPV costs
Total corrective labor costs: 26645.9134
Total planned labor costs: 32262.015
Total inspection labor costs: 0
Total corrective equipment costs: 0
Total planned equipment costs: 0
Total inspection equipment costs: 0
Corrective spare purchase costs: 70665.5611
Planned spare purchase costs: 33715.5796
Spare storage costs: 0
Corrective effect costs: 19489223.4
Planned effect costs: 0
Inspection effect costs: 0
Alarm costs: 14092.2768
Corrective operational costs: 0
Planned operational costs: 338822.173
Inspection operational costs: 0
Commission costs: 0
Redesign costs: 0

Total costs: 20005426.9

Safety criticality: 0.00371575628
Operational criticality: 0.000678268836
Environmental criticality: 0.000243207763
Spares volume level 1: 0
Spares volume level 2: 0
Spares weight level 1: 0
Spares weight level 2: 0
    
```

Close



Net Present Value

Decreasing NPV for Maintenance Costs:

- i. **Potential Positive Sign:** A decreasing NPV for maintenance costs is often viewed as positive because it suggests that the site is becoming more efficient and cost-effective over time.
- ii. **Reasons for Positivity:** This trend could indicate improved operational practices, cost-saving measures, technological advancements, or better utilization of resources.
- iii. **Potential Concerns:** However, it's important to ensure that the reduction in maintenance costs does not compromise safety, environmental compliance, or the long-term integrity of equipment. Cutting maintenance costs too aggressively can lead to safety and operational risks.

Increasing NPV for Maintenance Costs:

- i. **Potential Positive Sign:** An increasing NPV for maintenance costs may be positive if it is due to necessary investments in infrastructure and equipment maintenance to ensure safe and reliable operations.
- ii. **Reasons for Positivity:** This trend might indicate that the site is proactively addressing maintenance and asset integrity concerns, which can prevent costly breakdowns or accidents in the future.
- iii. **Potential Concerns:** On the other hand, if increasing maintenance costs are due to inefficiencies, aging equipment, or unexpected breakdowns, it could be a sign of operational challenges and financial strain.



THE 21ST INTERNATIONAL
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CONFERENCE IN THE ARAB COUNTRIES

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