OMAINTEC CONFERENCE 2024 EXHIBITION

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

Digital Twins Unveiled

Simulating Asset Performance for Optimal Management

#OmaintecConf

An Initiative by

OMAINTEC
المجلس العربي للتشغيل والصيانة
Arab Operations & Maintenance Council

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)

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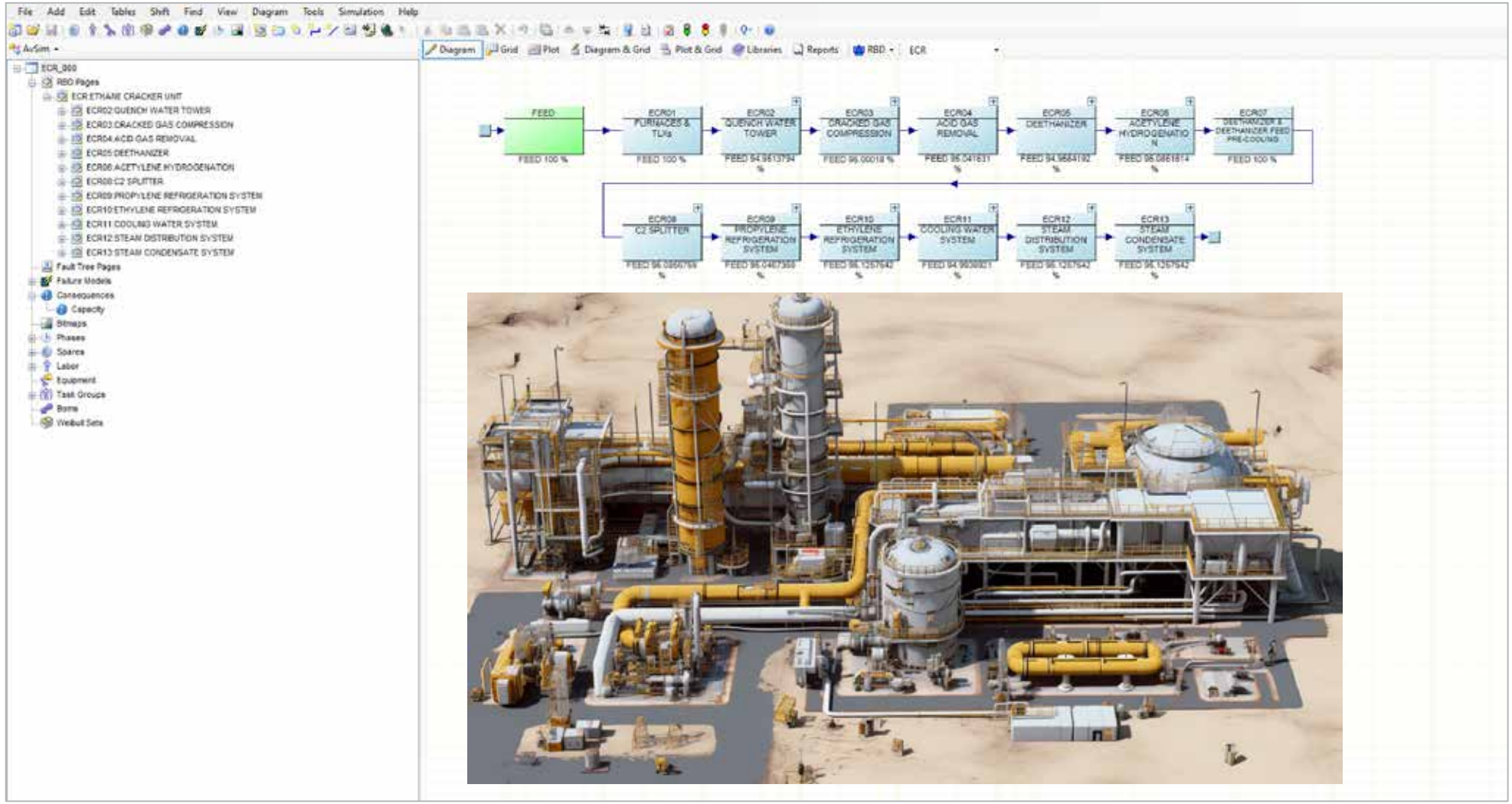
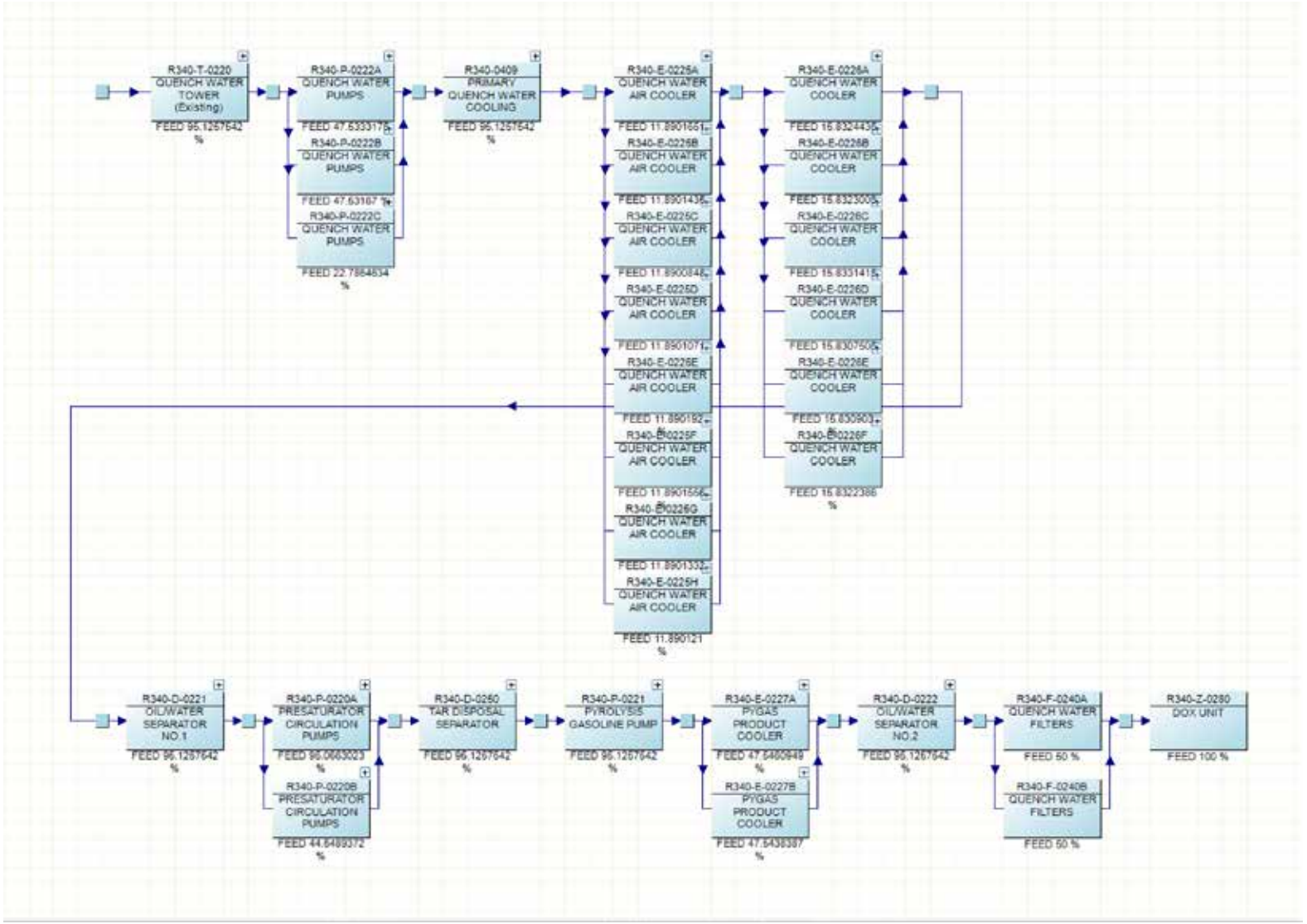
Case Study

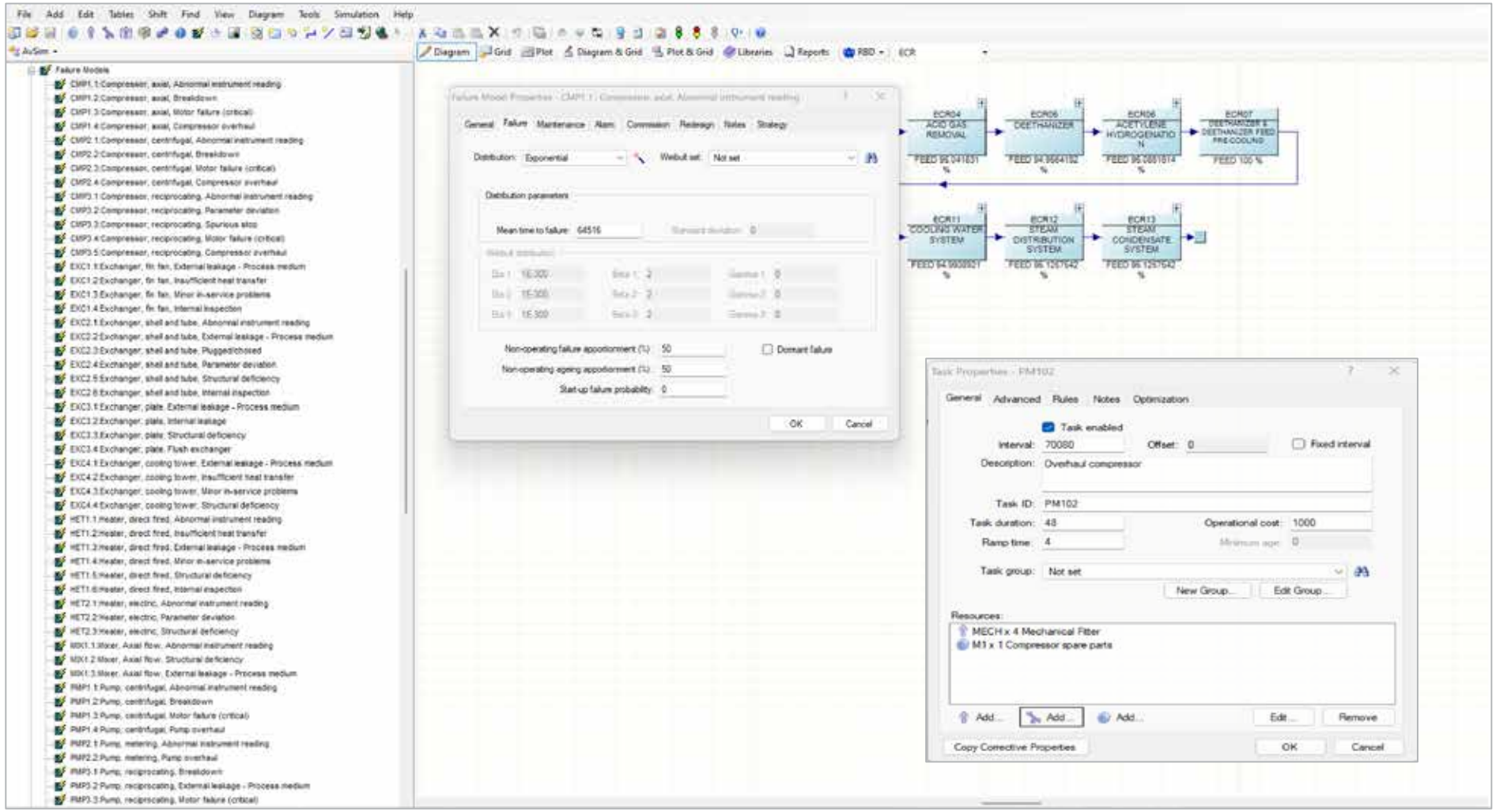
Case Study


File Add Edit Tables Shift Find View Diagram Tools Simulation Help
Diagram Grid Plot Diagram & Grid Plot & Grid Libraries Reports RBD ECR
ECR_000
RBD Pages
ECR ETHANE CRACKER UNIT
ECR02 QUENCH WATER TOWER
ECR03 CRACKED GAS COMPRESSION
ECR04 ACID GAS REMOVAL
ECR05 DEETHANIZER
ECR06 ACETYLENE HYDROGENATION
ECR08 C2 SPLITTER
ECR09 PROPYLENE REFRIGERATION SYSTEM
ECR10 ETHYLENE REFRIGERATION SYSTEM
ECR11 COOLING WATER SYSTEM
ECR12 STEAM DISTRIBUTION SYSTEM
ECR13 STEAM CONDENSATE SYSTEM
Fault Tree Pages
Failure Modes
Consequences
Capacity
Bitmaps
Phases
Spares
Labor
Equipment
Task Groups
Borns
Weibull Sets
FEED
ECR01 FURNACES & TLXs
ECR02 QUENCH WATER TOWER
ECR03 CRACKED GAS COMPRESSION
ECR04 ACID GAS REMOVAL
ECR05 DEETHANIZER
ECR06 ACETYLENE HYDROGENATIO N
ECR07 DEETHANIZER & DEETHANIZER FEED PRE-COOLING
ECR08 C2 SPLITTER
ECR09 PROPYLENE REFRIGERATION SYSTEM
ECR10 ETHYLENE REFRIGERATION SYSTEM
ECR11 COOLING WATER SYSTEM
ECR12 STEAM DISTRIBUTION SYSTEM
ECR13 STEAM CONDENSATE SYSTEM

Case Study


R340-T-0220
QUENCH WATER TOWER (Existing)
FEED 95.1267642 %
R340-P-0222A
QUENCH WATER PUMPS
FEED 47.5333178 %
R340-P-0222B
QUENCH WATER PUMPS
FEED 47.63167 %
R340-P-0222C
QUENCH WATER PUMPS
FEED 22.7864834 %
R340-0409
PRIMARY QUENCH WATER COOLING
FEED 95.1267642 %
R340-E-0225A
QUENCH WATER AIR COOLER
FEED 11.8901651 %
R340-E-0225B
QUENCH WATER AIR COOLER
FEED 11.8901438 %
R340-E-0225C
QUENCH WATER AIR COOLER
FEED 11.8900848 %
R340-E-0225D
QUENCH WATER AIR COOLER
FEED 11.8901071 %
R340-E-0225E
QUENCH WATER AIR COOLER
FEED 11.890192 %
R340-E-0225F
QUENCH WATER AIR COOLER
FEED 11.8901556 %
R340-E-0225G
QUENCH WATER AIR COOLER
FEED 11.8901332 %
R340-E-0225H
QUENCH WATER AIR COOLER
FEED 11.890121 %
R340-E-0226A
QUENCH WATER COOLER
FEED 15.8324435 %
R340-E-0226B
QUENCH WATER COOLER
FEED 15.8323003 %
R340-E-0226C
QUENCH WATER COOLER
FEED 15.8331415 %
R340-E-0226D
QUENCH WATER COOLER
FEED 15.8307503 %
R340-E-0226E
QUENCH WATER COOLER
FEED 15.8309803 %
R340-E-0226F
QUENCH WATER COOLER
FEED 15.8322386 %
R340-D-0221
OIL/WATER SEPARATOR NO.1
FEED 95.1267642 %
R340-P-0220A
PRESATURATOR CIRCULATION PUMPS
FEED 95.0663023 %
R340-P-0220B
PRESATURATOR CIRCULATION PUMPS
FEED 44.6489372 %
R340-D-0250
TAR DISPOSAL SEPARATOR
FEED 95.1267642 %
R340-P-0221
PYROLYSIS GASOLINE PUMP
FEED 95.1267642 %
R340-E-0227A
PYGAS PRODUCT COOLER
FEED 47.5400849 %
R340-E-0227B
PYGAS PRODUCT COOLER
FEED 47.5438387 %
R340-D-0222
OIL/WATER SEPARATOR NO.2
FEED 95.1267642 %
R340-F-0240A
QUENCH WATER FILTERS
FEED 50 %
R340-F-0240B
QUENCH WATER FILTERS
FEED 50 %
R340-Z-0280
DOX UNIT
FEED 100 %

Case Study



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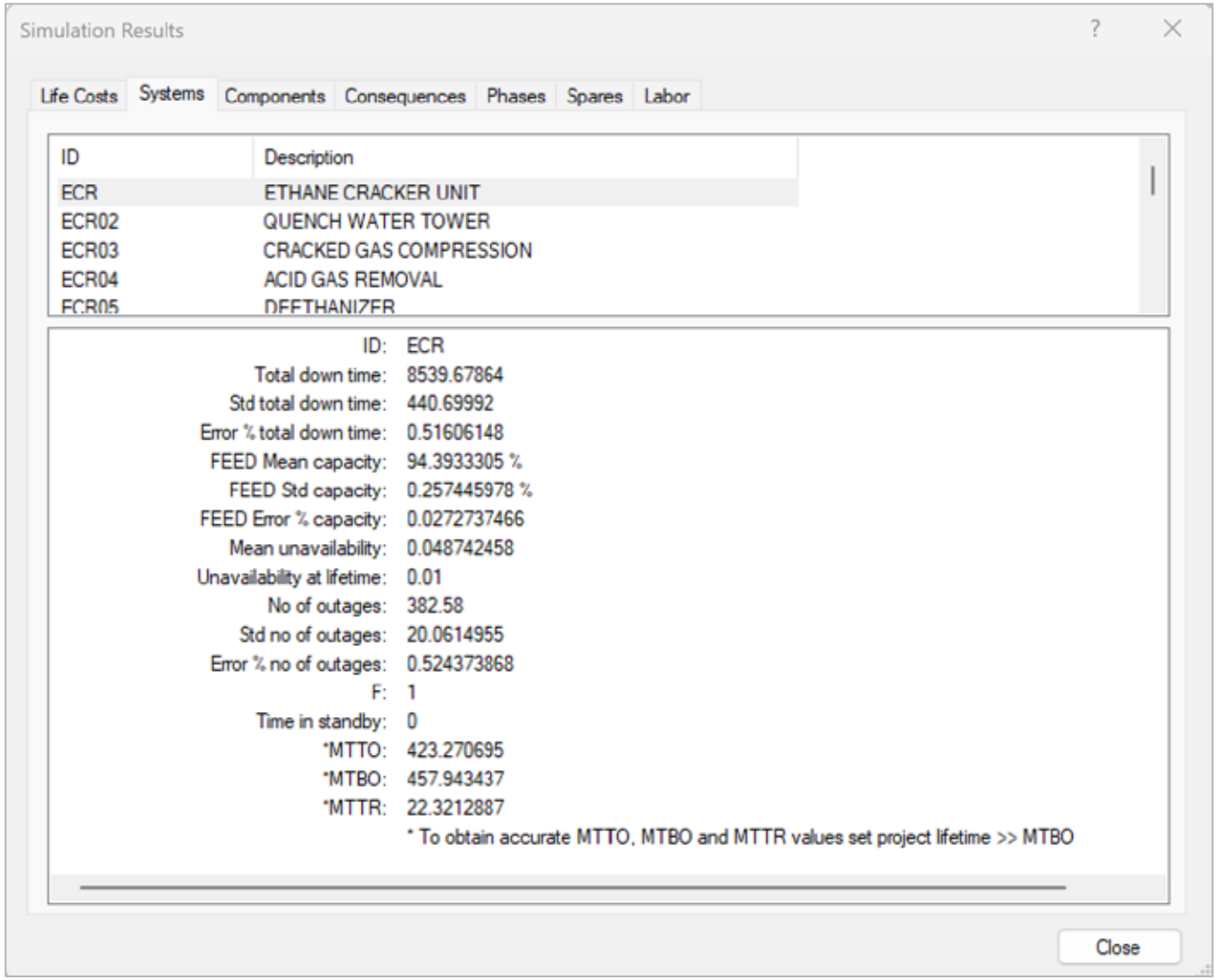
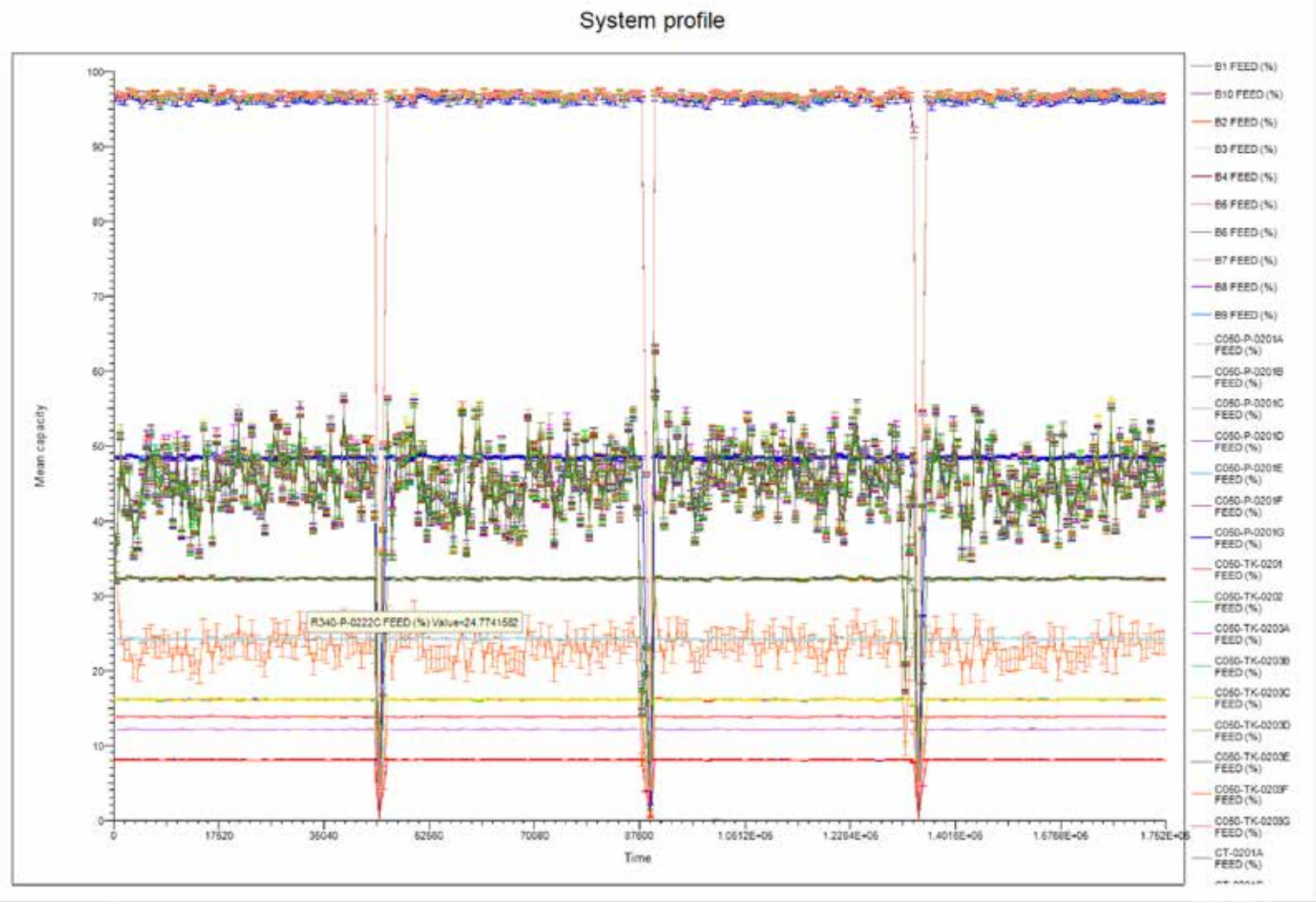
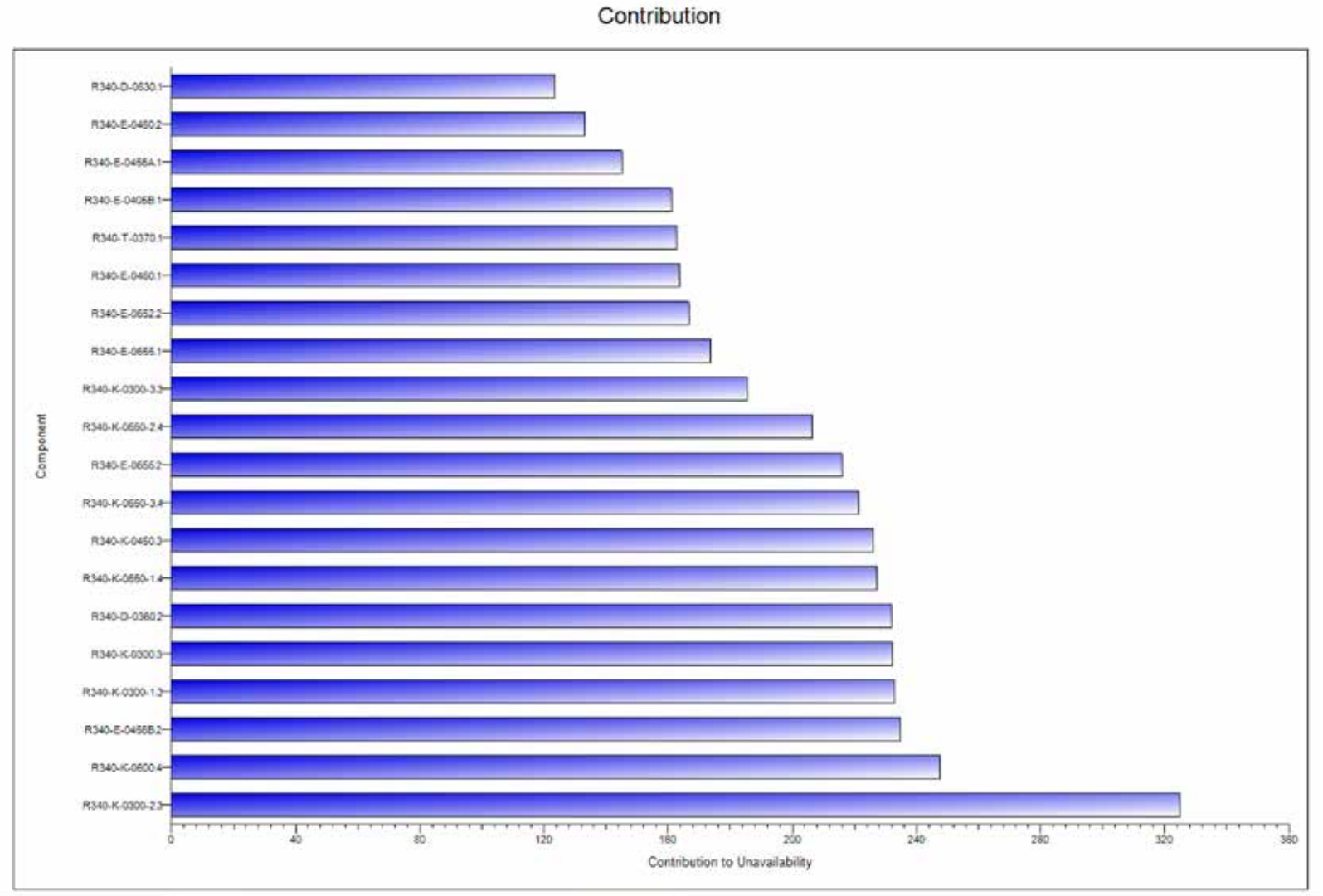
Case Study


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
ECR05
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

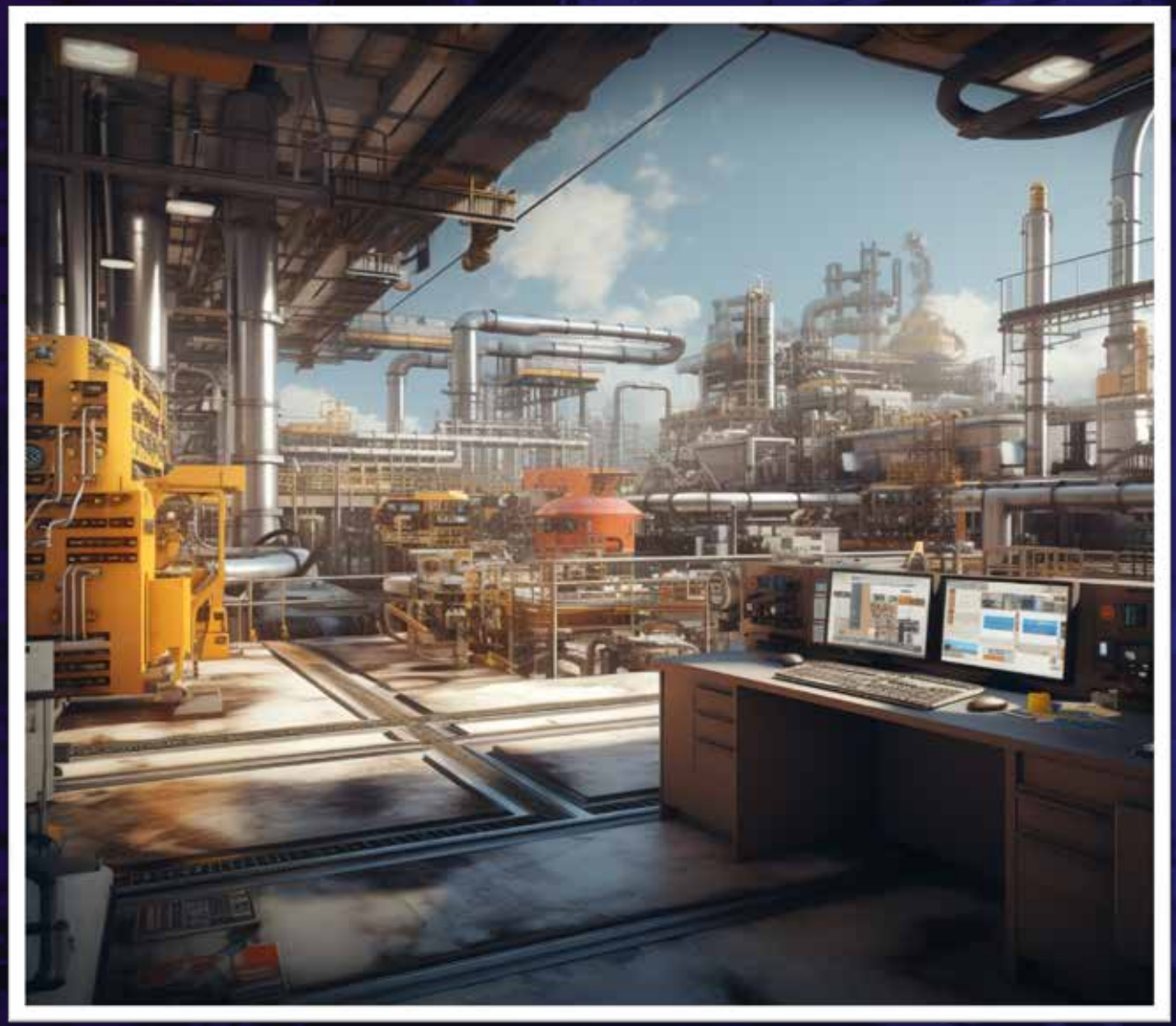
Case Study


System profile
Mean capacity
Time
R340-P-0222C FEED (%) Value=24.7741582
B1 FEED (%)
B10 FEED (%)
B2 FEED (%)
B3 FEED (%)
B4 FEED (%)
B5 FEED (%)
B6 FEED (%)
B7 FEED (%)
B8 FEED (%)
B9 FEED (%)
C050-P-0201A FEED (%)
C050-P-0201B FEED (%)
C050-P-0201C FEED (%)
C050-P-0201D FEED (%)
C050-P-0201E FEED (%)
C050-P-0201F FEED (%)
C050-P-0201G FEED (%)
C050-TK-0201 FEED (%)
C050-TK-0202 FEED (%)
C050-TK-0203A FEED (%)
C050-TK-0203B FEED (%)
C050-TK-0203C FEED (%)
C050-TK-0203D FEED (%)
C050-TK-0203E FEED (%)
C050-TK-0203F FEED (%)
C050-TK-0203G FEED (%)
CT-0201A FEED (%)

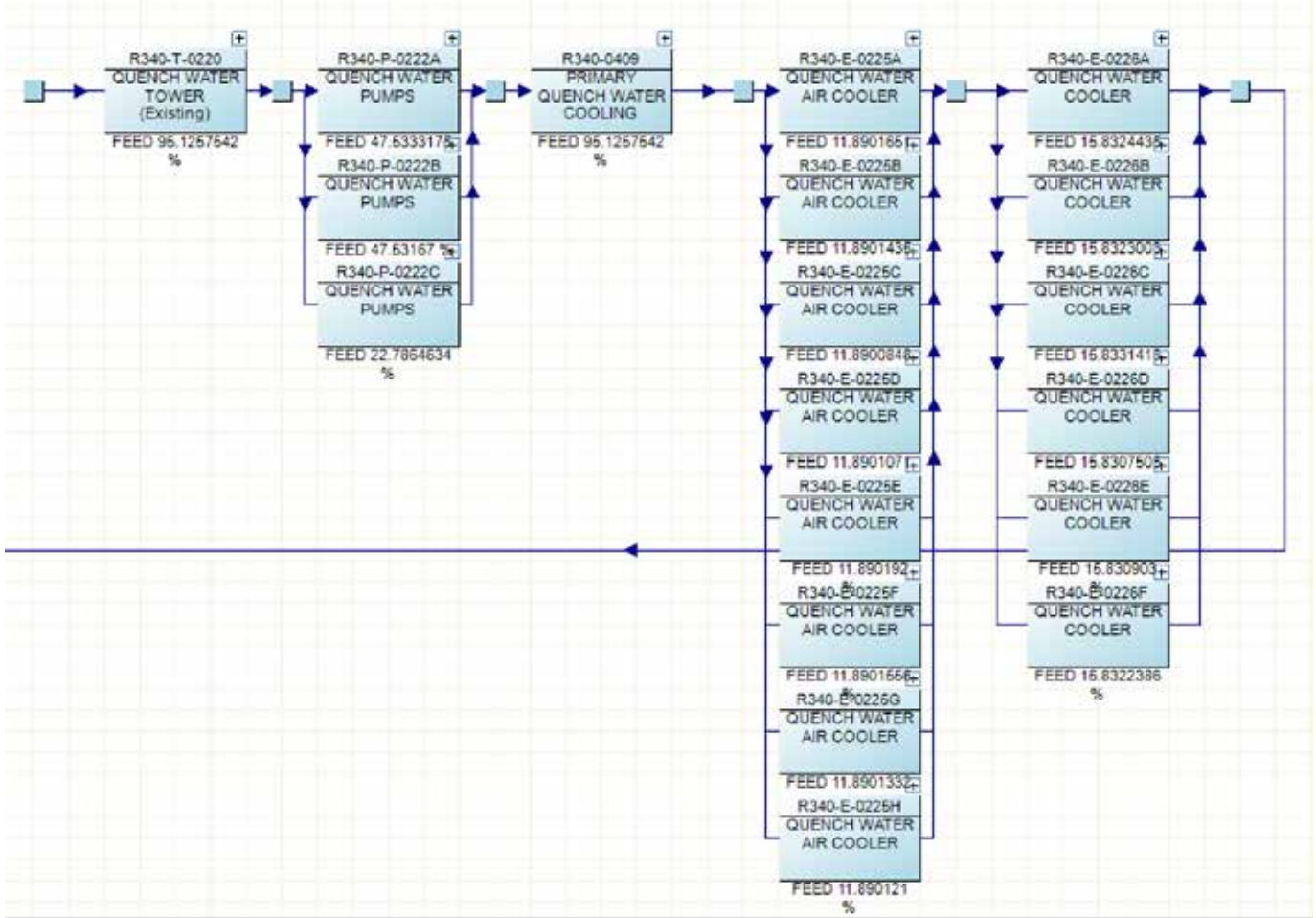
Case Study


Contribution
Component
R340-D-0630.1
R340-E-0460.2
R340-E-0456A.1
R340-E-0456B.1
R340-T-0370.1
R340-E-0460.1
R340-E-0652.2
R340-E-0656.1
R340-K-0300-3.3
R340-K-0660-2.4
R340-E-0656.2
R340-K-0660-3.4
R340-K-0450.3
R340-K-0660-1.4
R340-D-0380.2
R340-K-0300.3
R340-K-0300-1.3
R340-E-0456B.2
R340-K-0600.4
R340-K-0300-2.3
0
40
80
120
160
200
240
280
320
360
Contribution to Unavailability

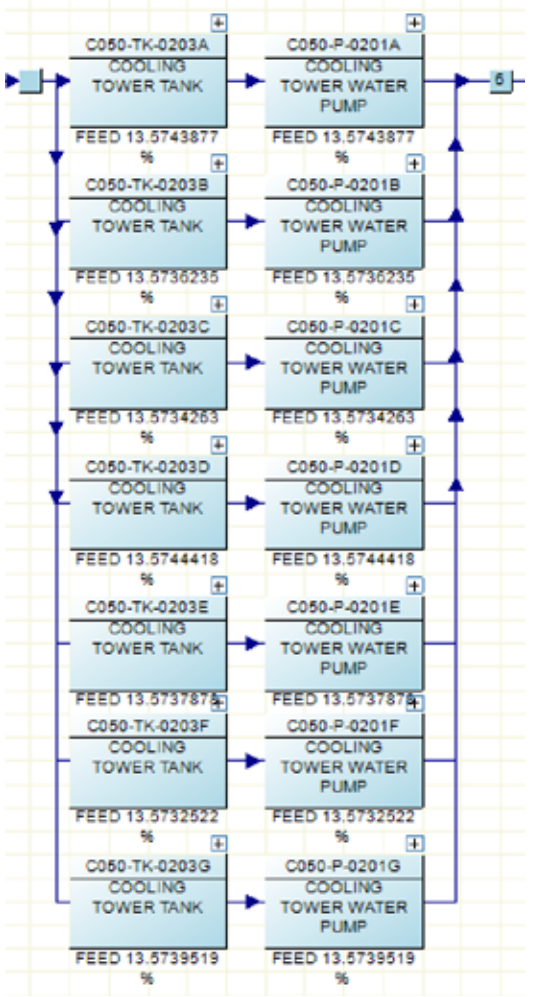
RBD Modelling & Techniques



Redundancy Arrangements



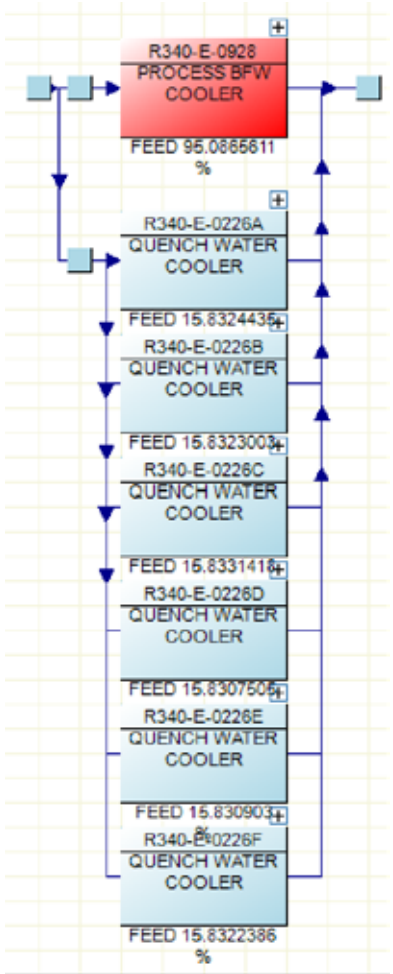
BASED ON NODE PRODUCTION DEMAND



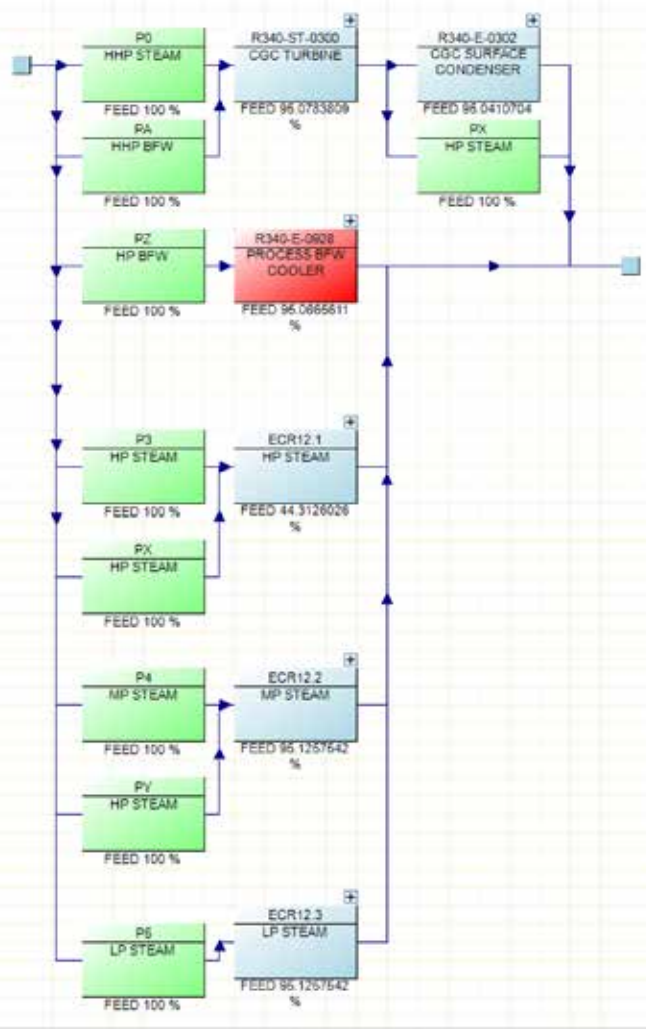
BASED ON NODE VOTE DEMAND

Common Assets

Exchanger in a steam system and product system

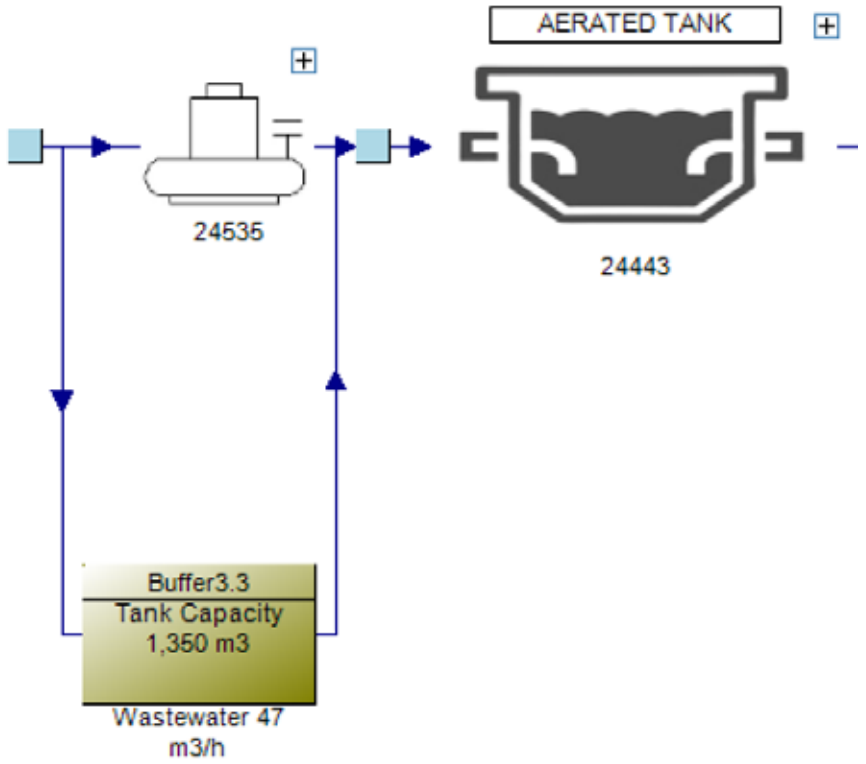


QUENCH WATER TOWER

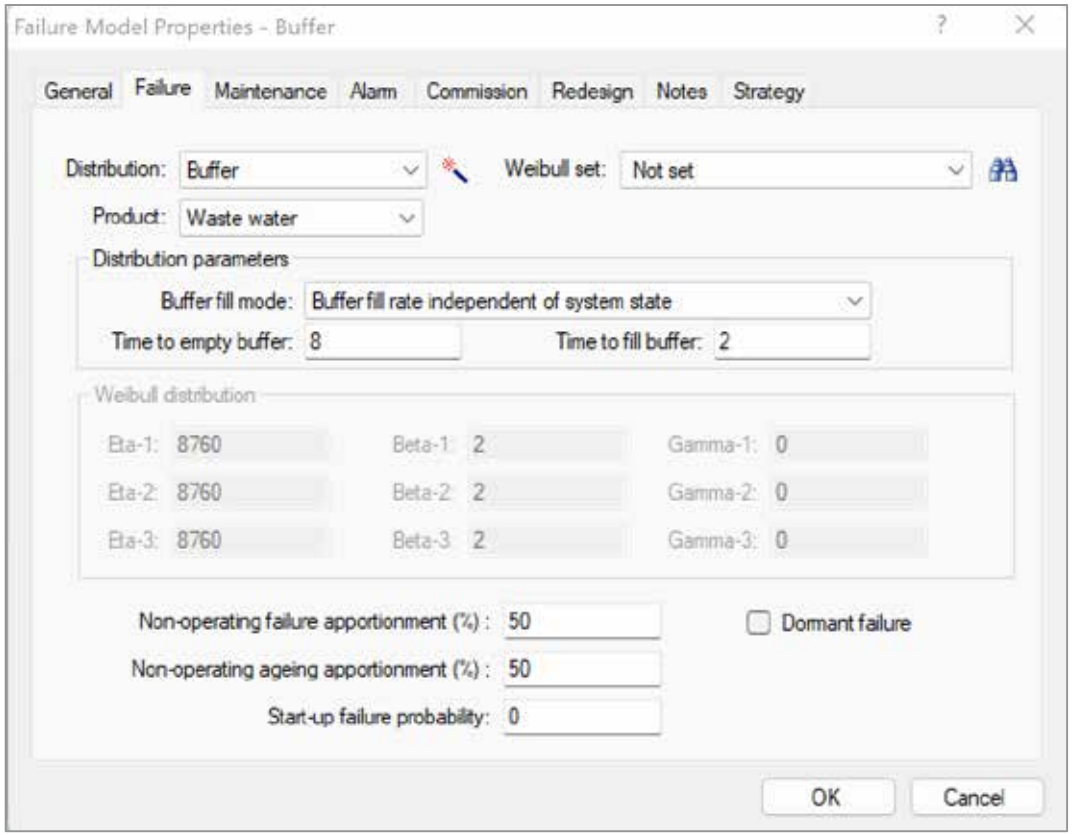


STEAM DISTRIBUTION SYSTEM

Tank Storage and Buffer Capacity

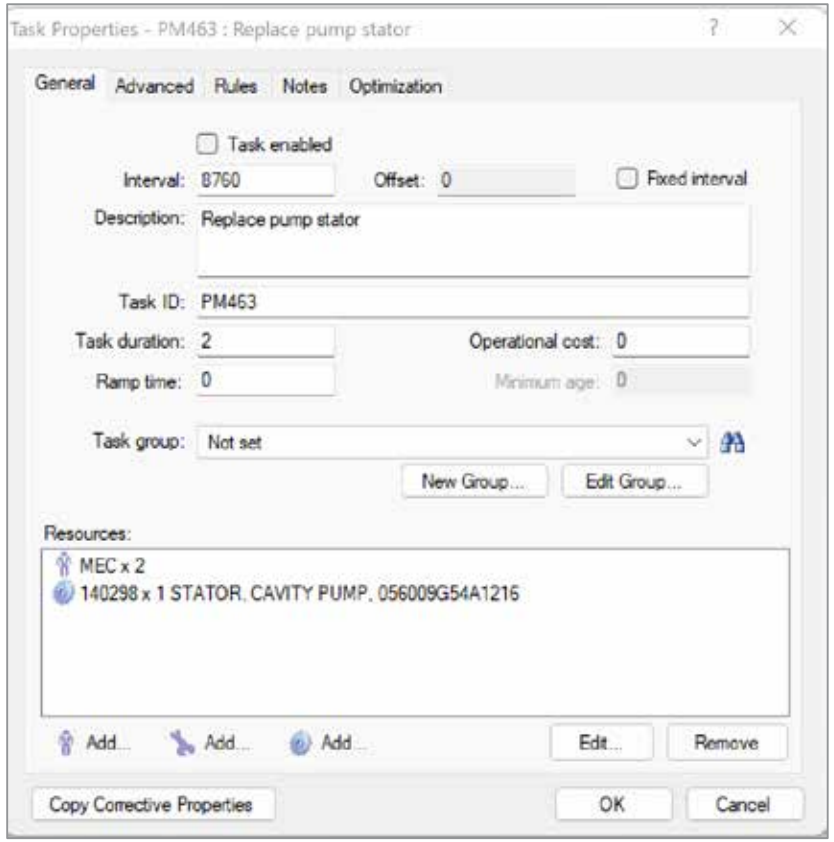


TANK CAPACITY OF 1,350 m^3

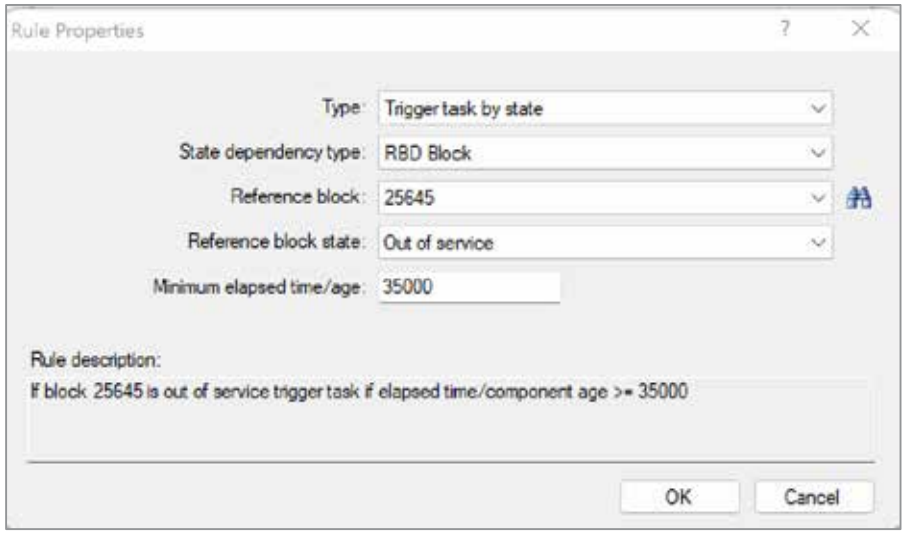


TANK TAKES 8 HOURS TO EMPTY AND 2 TO FILL

Opportunistic Maintenance

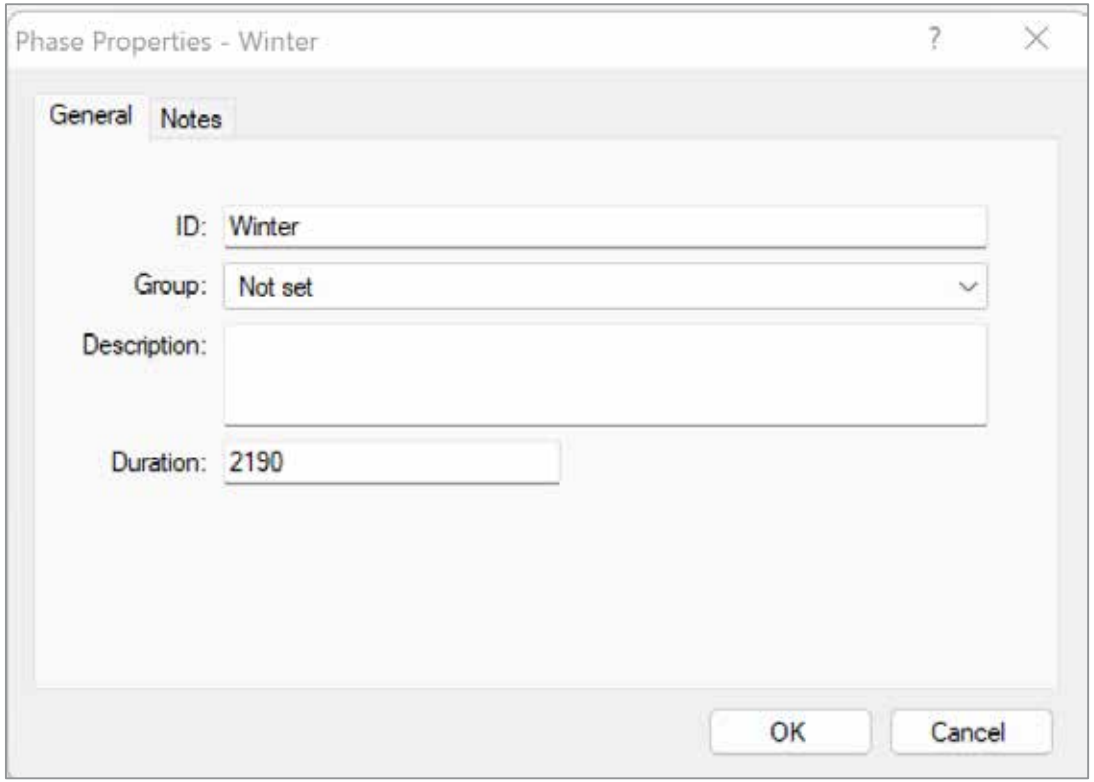


PLANNED MAINTENANCE

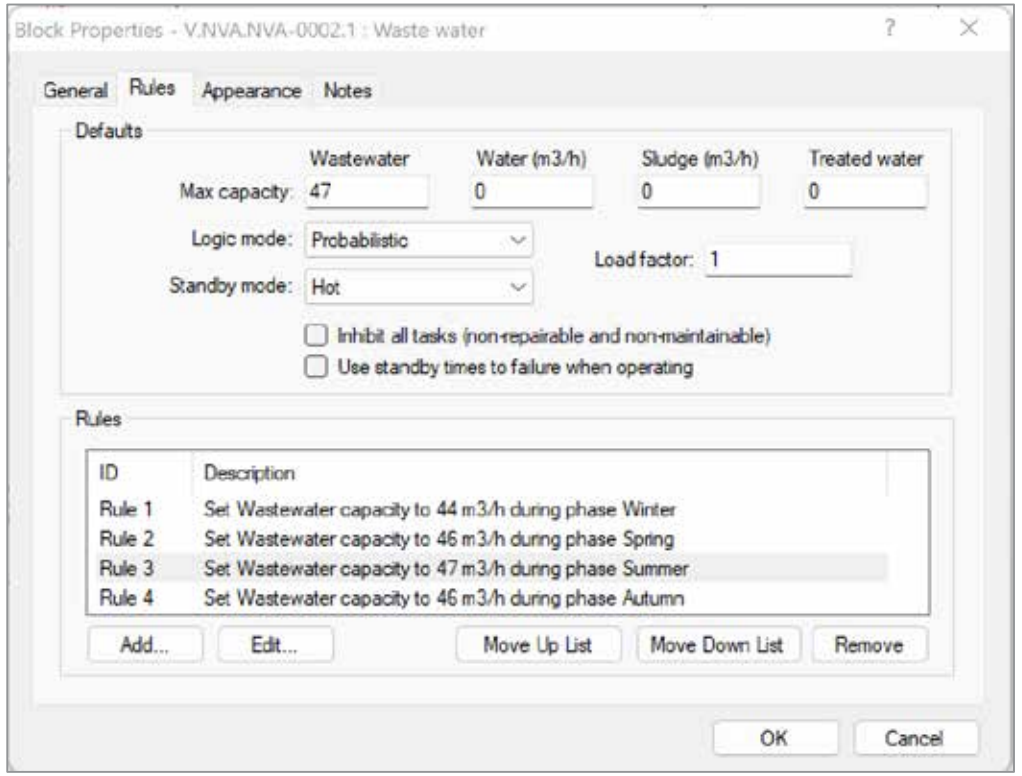


OUT OF SERVICE

Phases



PHASES FOR SEASONS



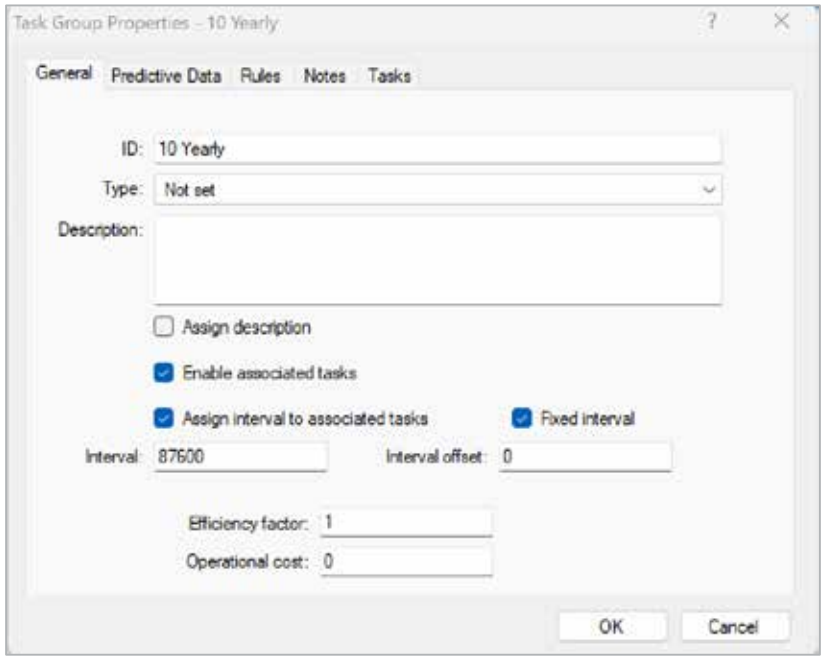
CHANGING OF CAPACITY FOR WASTEWATER DURING SEASONS

Shutdowns, Turnarounds & Inspection

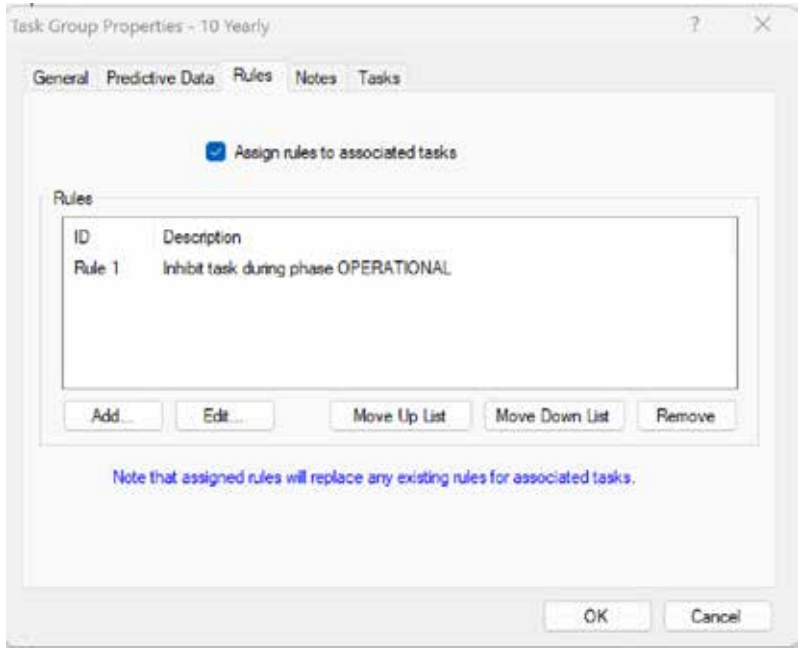
ID	Asset Type	E	Event Type	Failure	Failure Mode	MTBF	MTTR	Task Description
CMP1	Compressor, axial	4	Planned	Fixed	Compressor overhaul	87,600	336	Compressor major overhaul
CMP2	Compressor, centrifugal	4	Planned	Fixed	Compressor overhaul	87,600	336	Compressor major overhaul
CMP3	Compressor, reciprocating	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, destillation 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)

SHUTDOWN MAINTENANCE AND INSPECTION TASKS

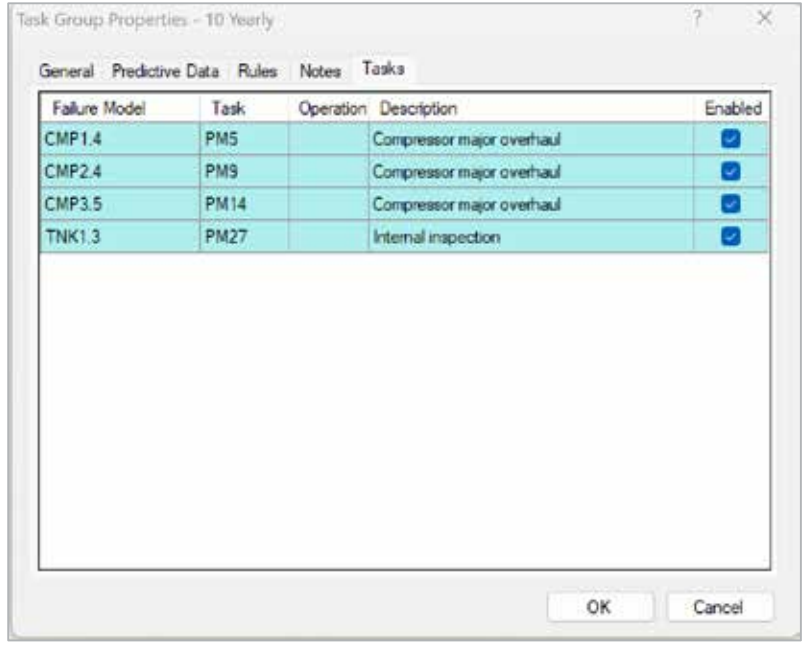
Shutdowns, Turnarounds & Inspection



TASK GROUP

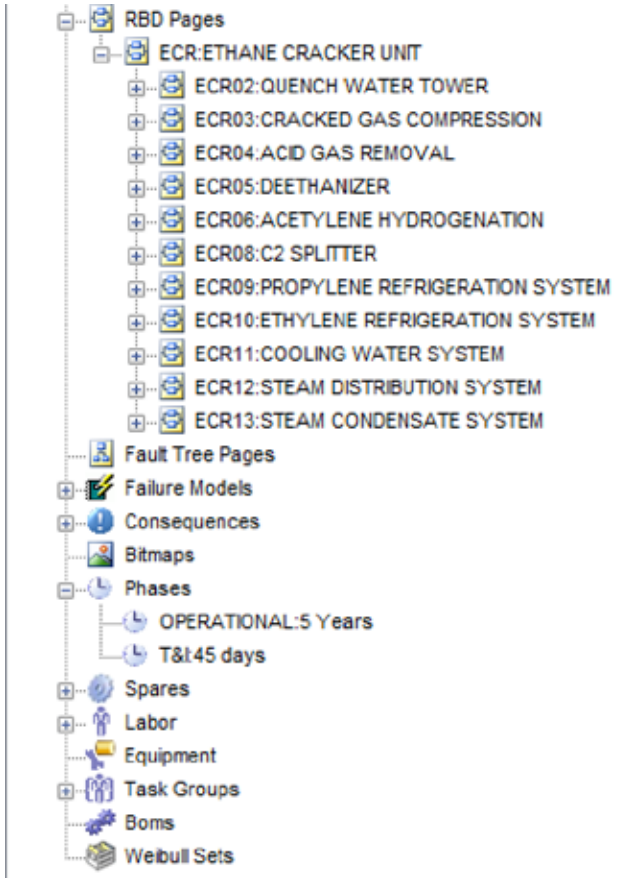


RULES TO ONLY PERFORM TASKS DURING T&I

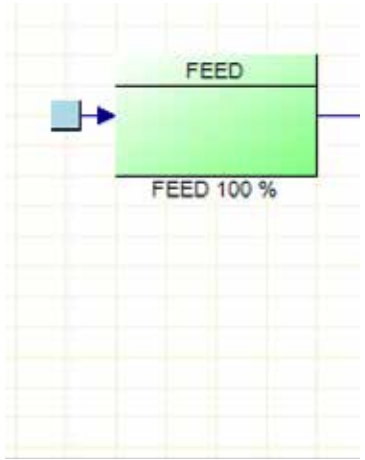


TASKS IN GROUP

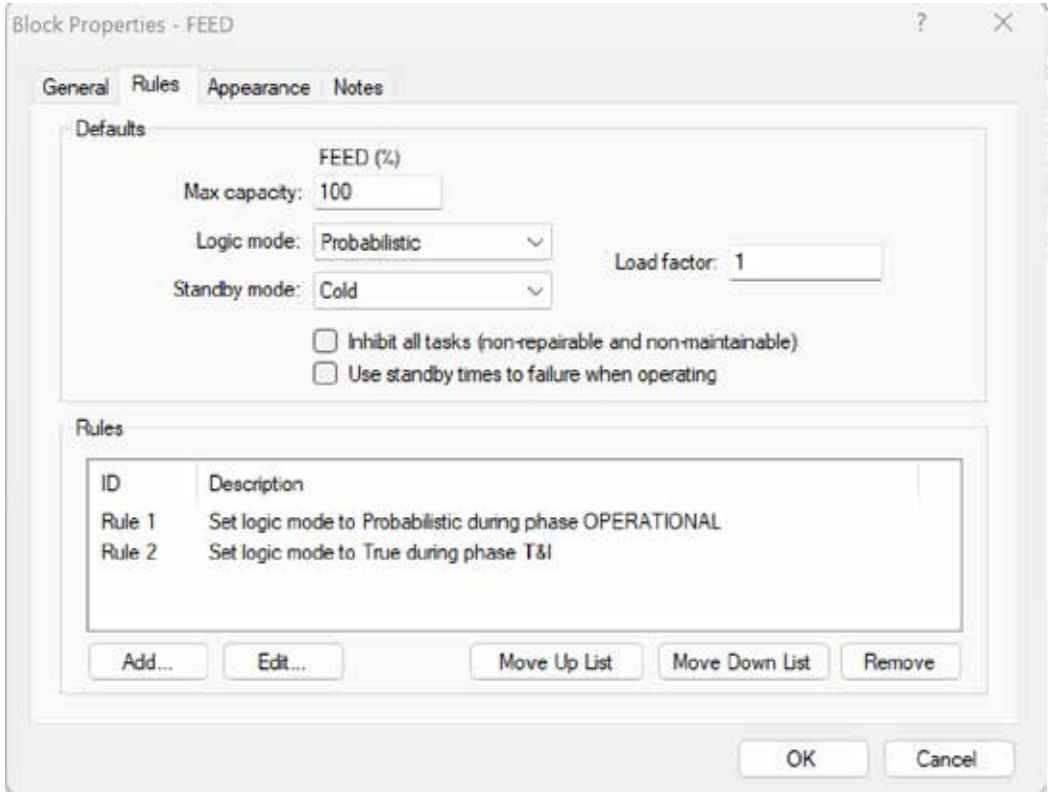
Shutdowns, Turnarounds & Inspection



SETUP PHASES

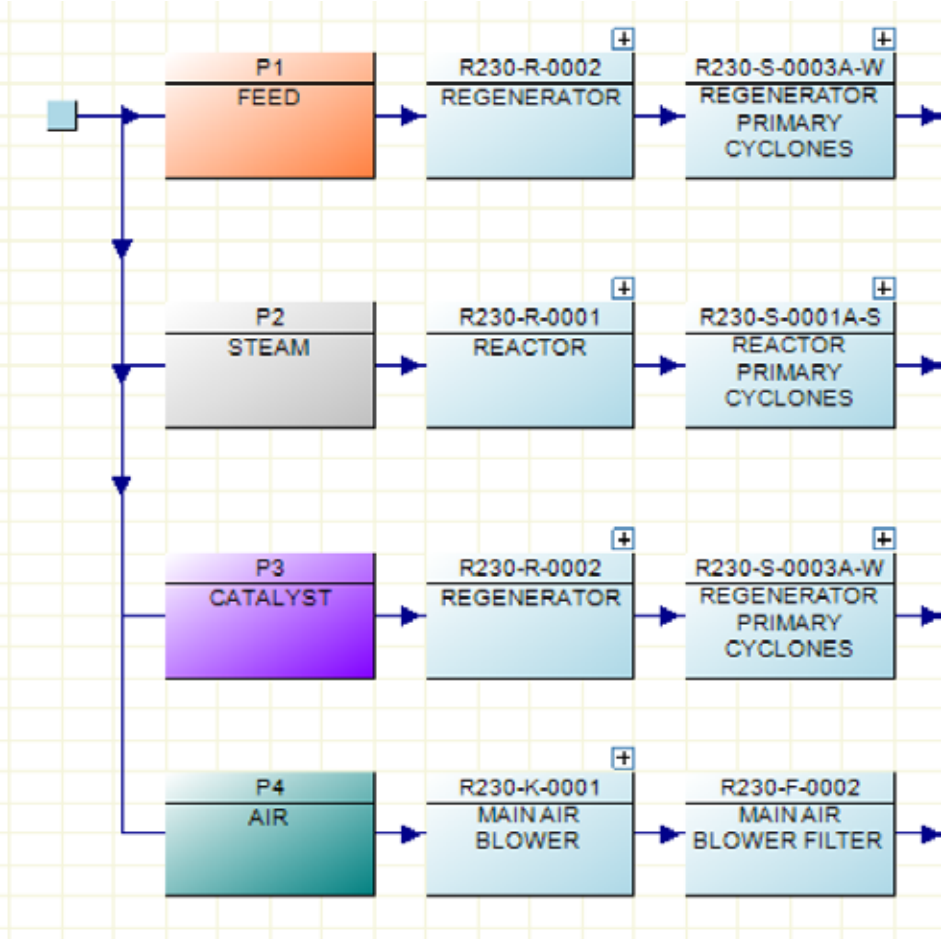


FEED BLOCK FOR MODEL CONSTRAINTS

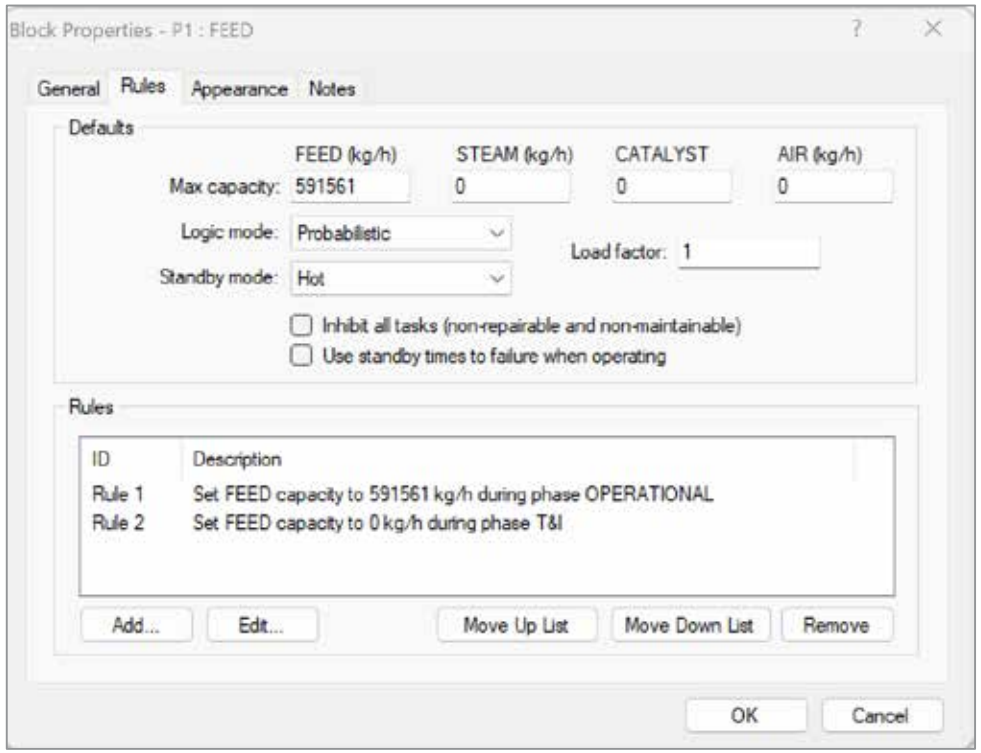


SET RULES PER PHASE

Shutdowns, Turnarounds & Inspection

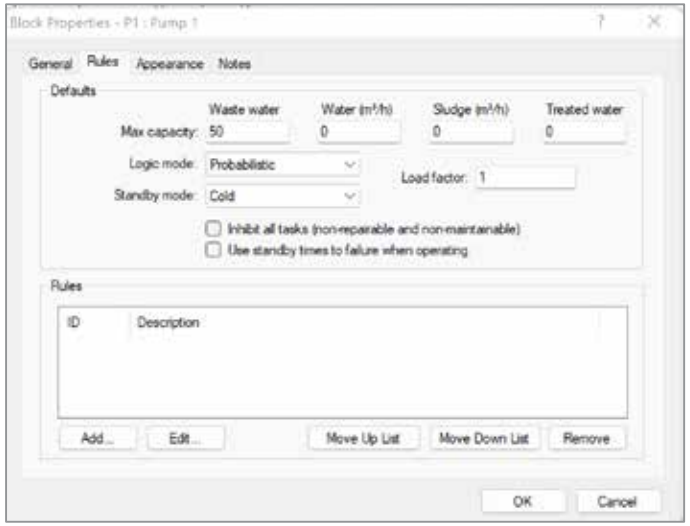


MULTIPLE FEED STREAMS

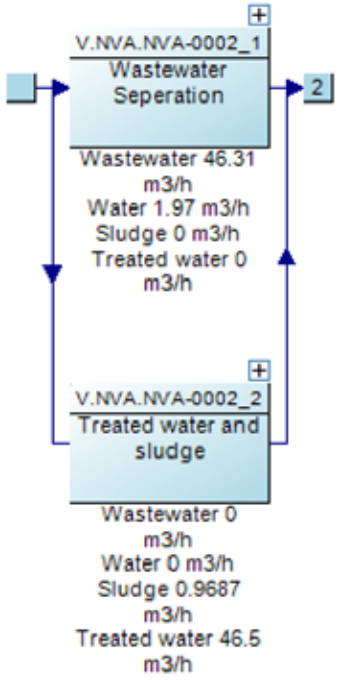


RULES TO SHUT OFF STREAMS DURING A SHUTDOWN

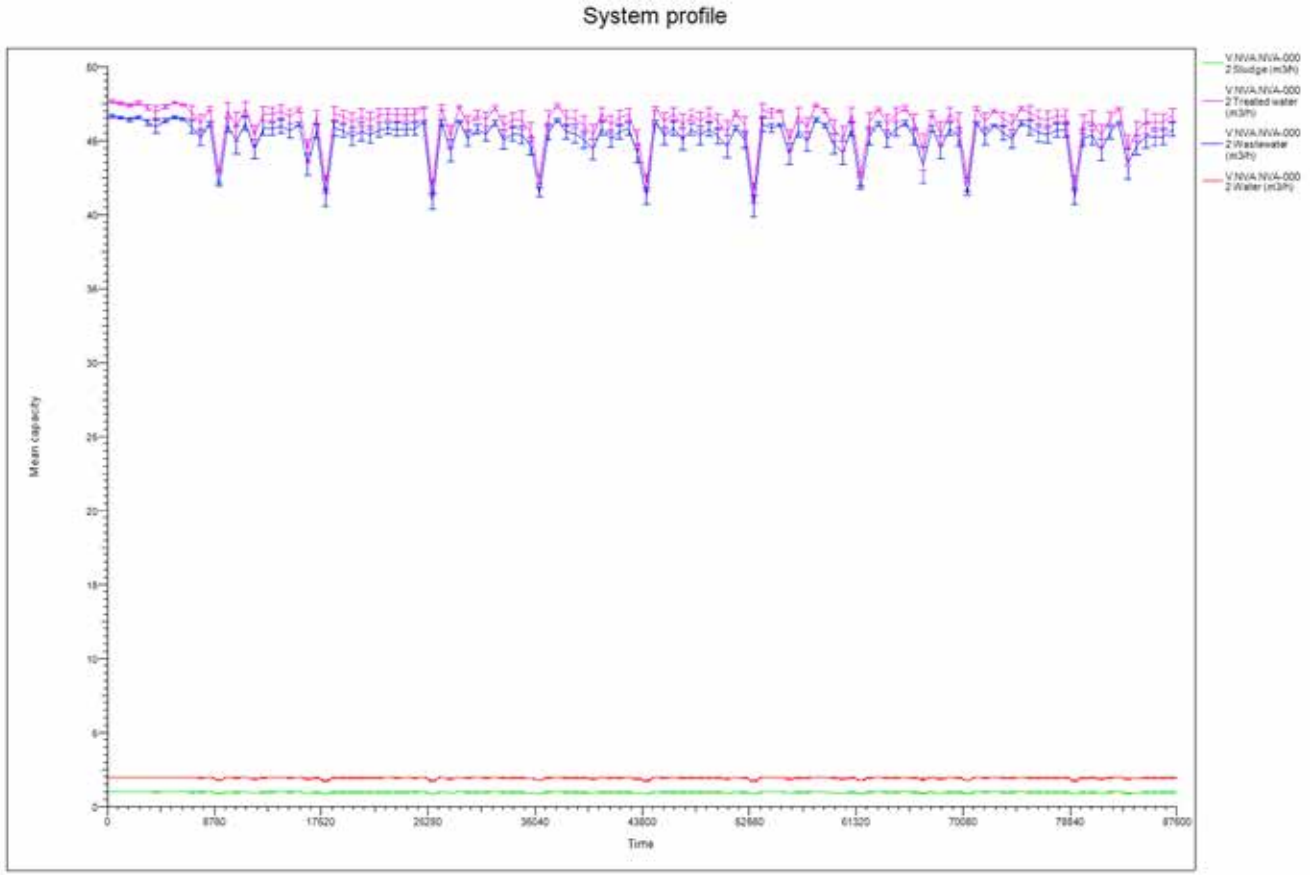
Production Modelling



PRODUCT CAPACITY SETUP

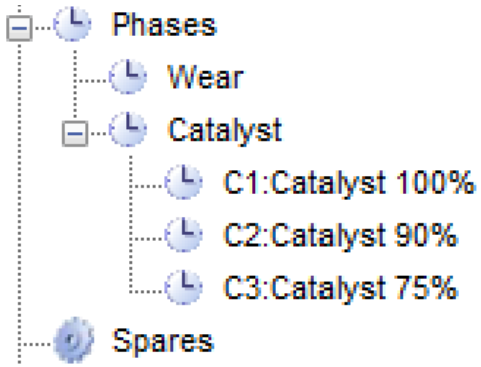


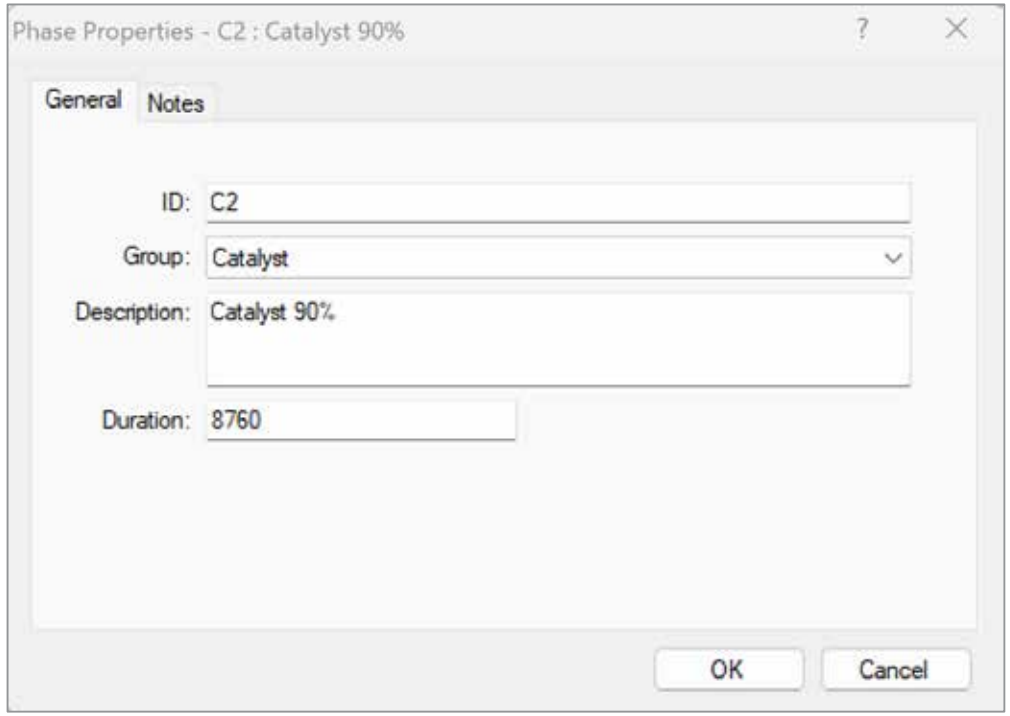
PARALLEL SYSTEMS

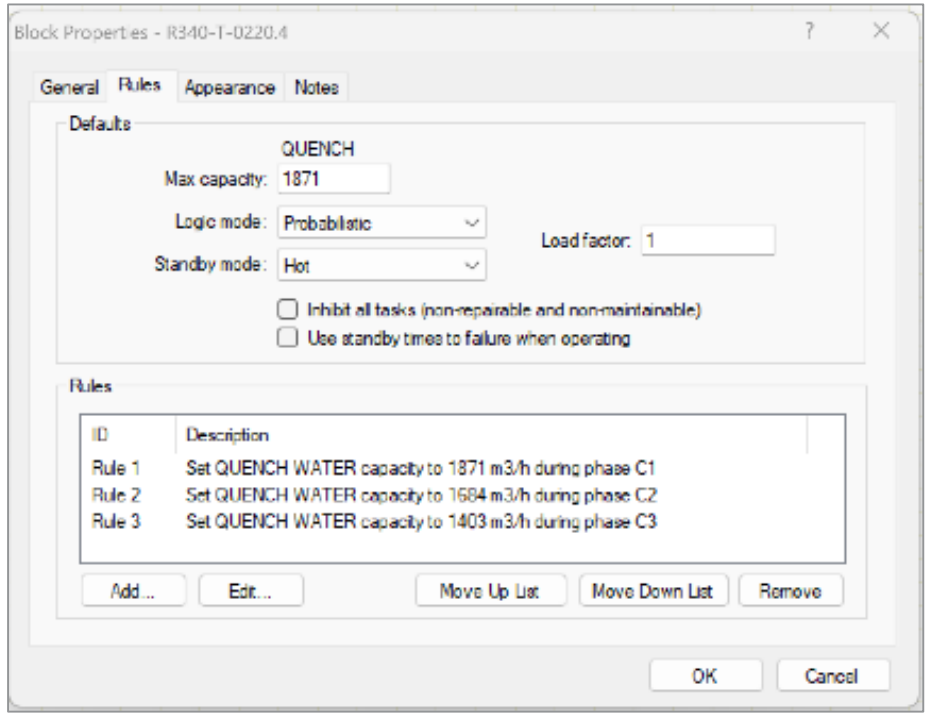


GRAPHICAL PRODUCTION OUTPUT OVER LIFECYCLE

Capacity Reduction





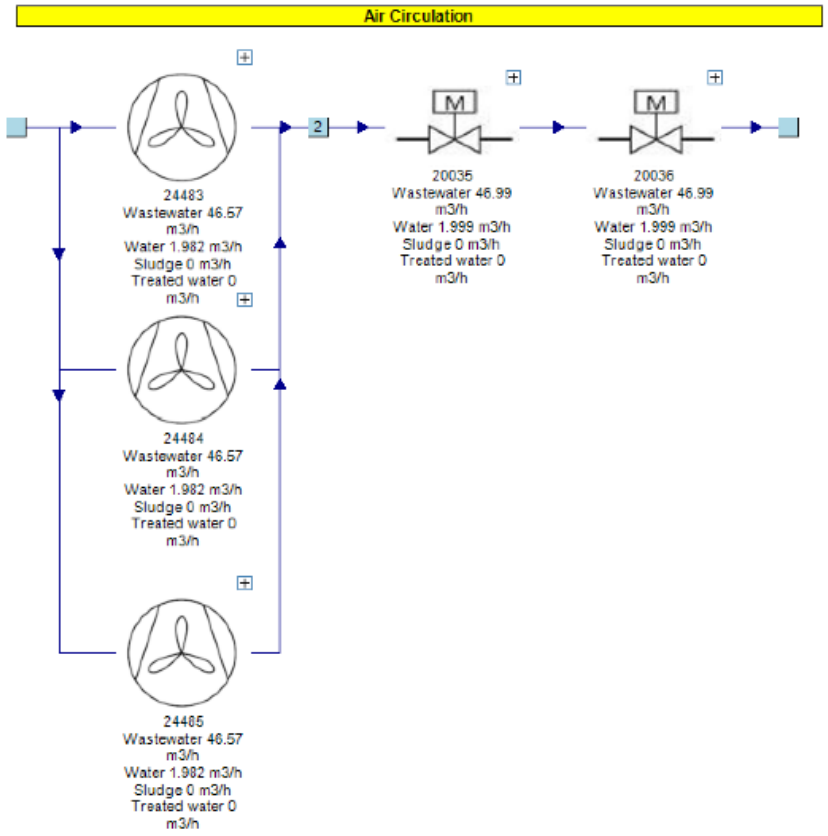


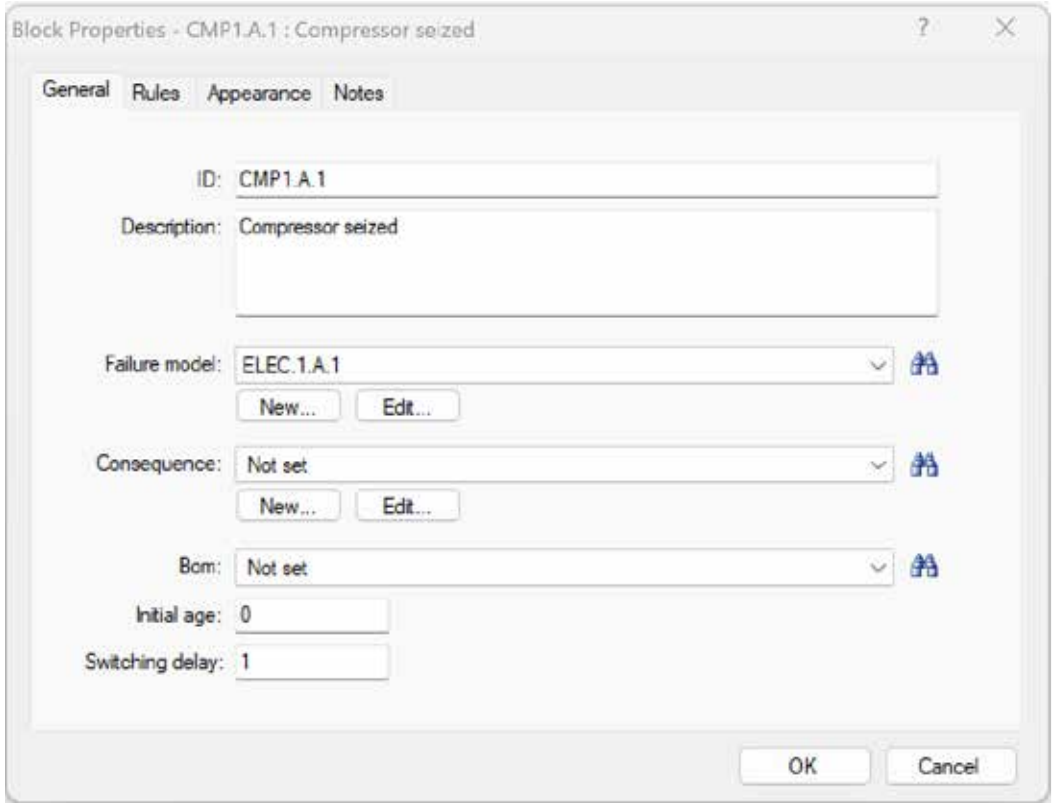
SETUP PHASES

PHASES DEFINITION

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

Switching Delay





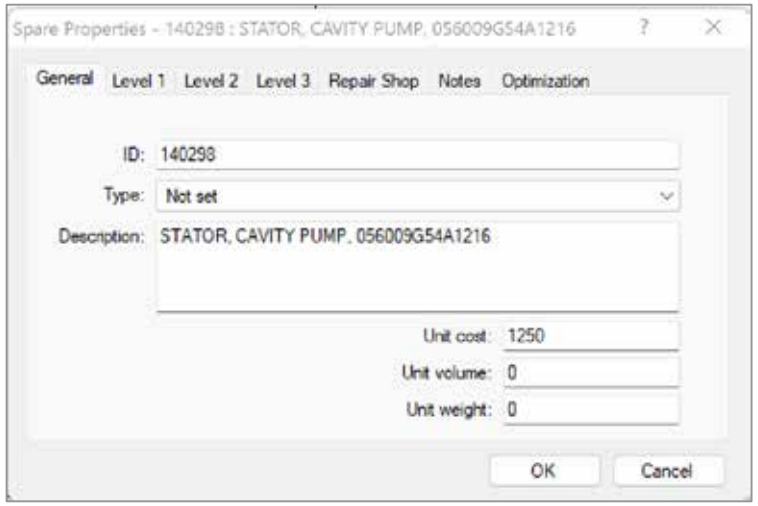
2 AIR BLOWERS ON DUTY WITH 1 IN STANDBY

1 HOUR SWITCHING DELAY WHEN 1 FAILS AND 3rd ENGAGES

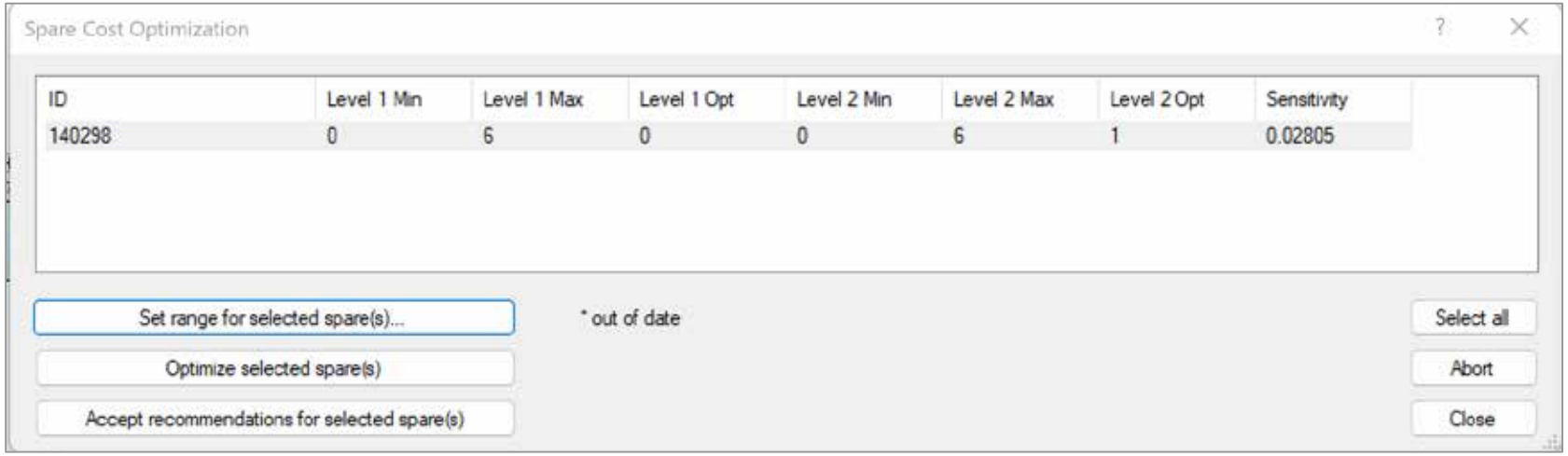
Spare Part Optimisation

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)



SPARE SETUP



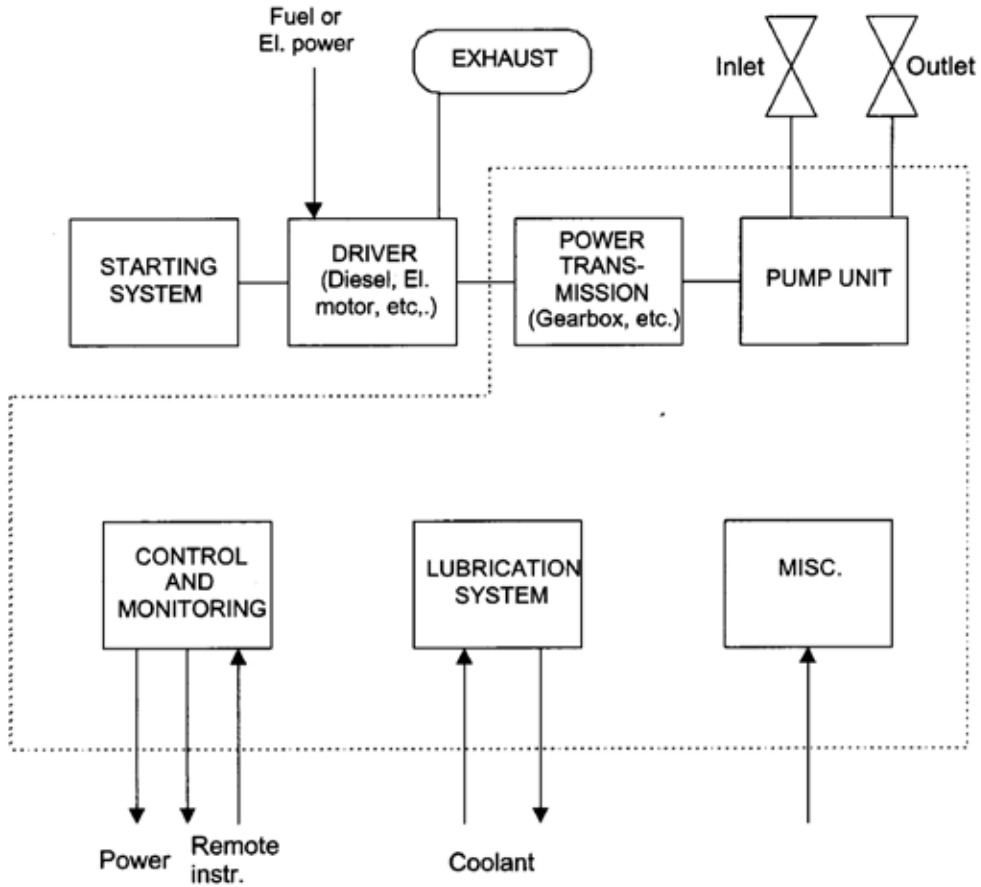
SPARE INVENTORY OPTIMISATION

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

OREDA



PUMP				
Power transmission	Pump	Control and Monitoring	Lubrication system	Miscellaneous
• Gearbox/var. drive • Bearing • Seals • Lubrication • Coupling to driver • Coupling to driven unit • Instruments	• Support • Casing • Impeller • Shaft • Radial bearing • Thrust bearing • Seals • Valves & piping • Cylinder liner[5] • Piston • Diaphragm[6] • Instruments	• Instruments • Cabling & junction boxes • Control unit • Actuating device • Monitoring • Internal power supply • Valves	• Instruments • Reservoir w/heating system • Pump w/motor • Filter • Cooler • Valves & piping • Oil • Seals	• Purge air • Cooling/heating system • Filter, cyclone • Pulsation damper

OREDA

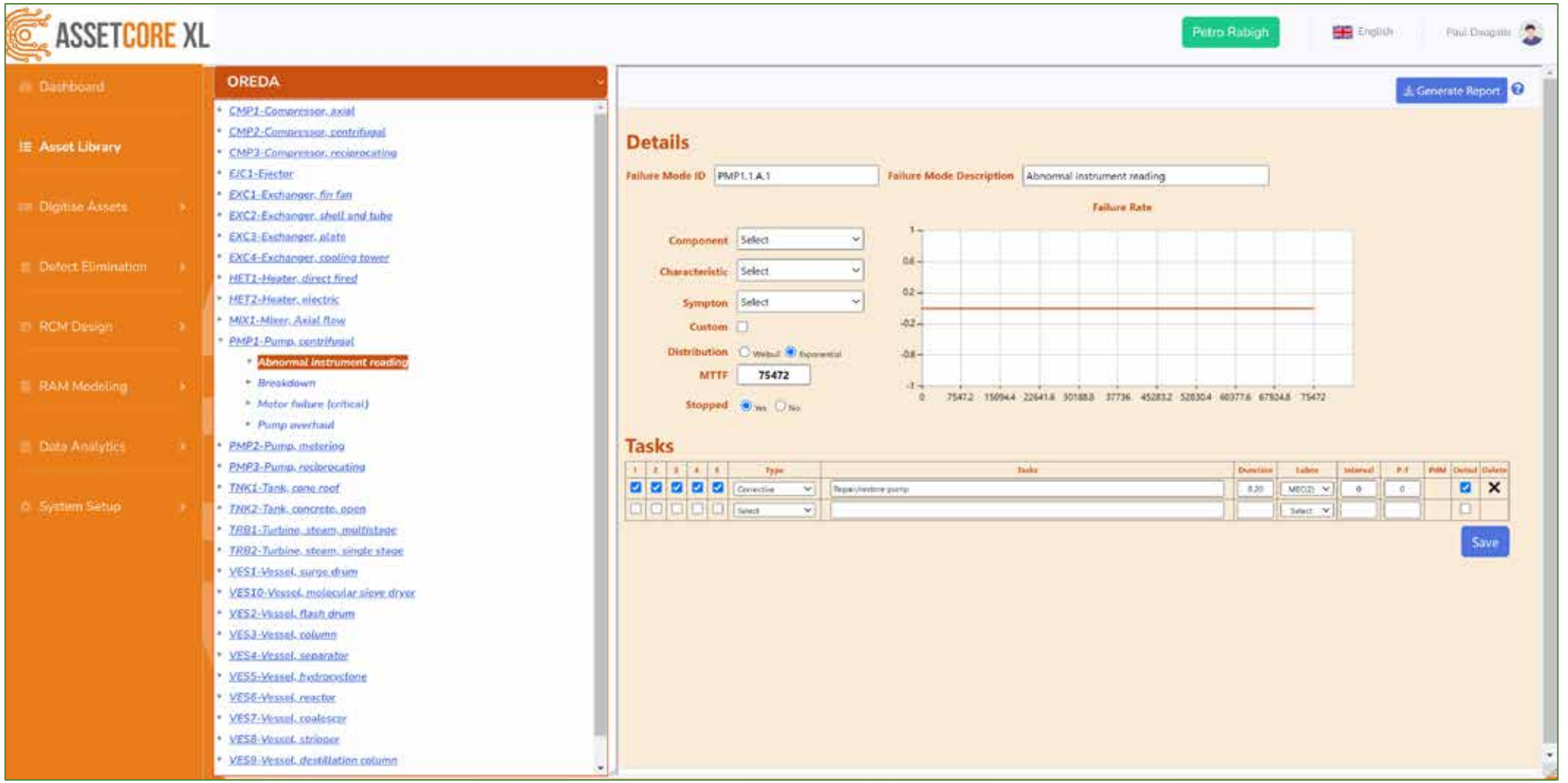
Taxonomy no	Item
1.3.1	Machinery Pumps Centrifugal

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
350	59	13.9546	5.7455	10340

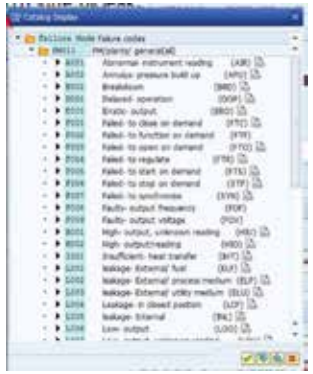
Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**464***	**0.00**	**21.60**	**124.23**	**67.21**	**33.25**	**39.7**	**1.0**	**57.6**	**1025.0**
	464†	**0.12**	**70.52**	**284.09**	**106.81**	**80.76**				
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

Asset Library

OREDA DATA IN ELECTRONIC FORMAT



Site Data



SYMPTOM
or FM
OREDA

Descriptions
helps for
data mining

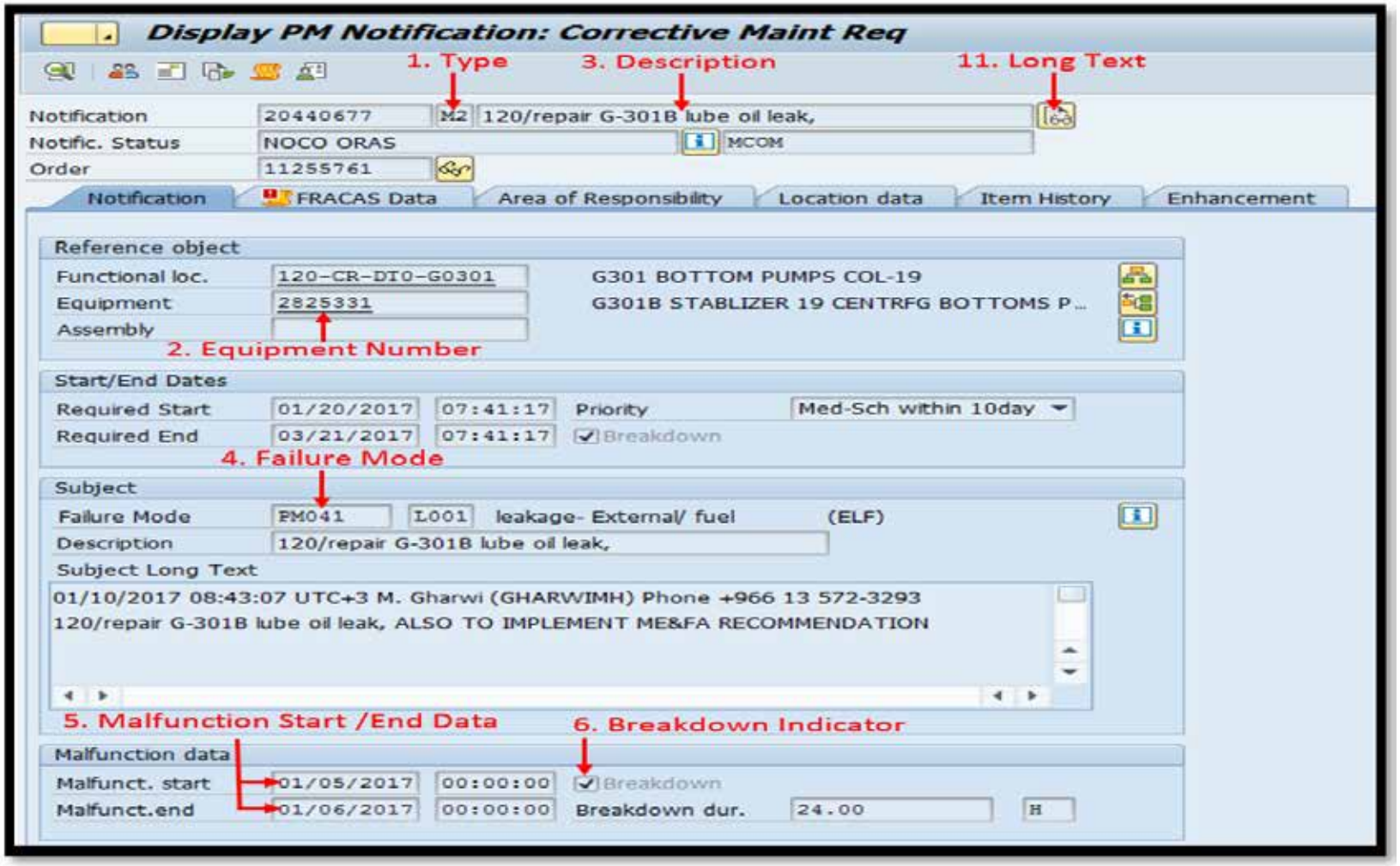


Figure [1-A] – Fields Evaluated in SAP

Equipment at tag level

Equipment assigned to classifications or asset types

Malfunction start is the MTBF calculated date

MEAN TIME TO REPAIR (MTTR) = 24.0 H

Site Data

Failure mode:

CASING-BOTTOM
TWISTED CAUSED BY
DESIGN_INCORRECT

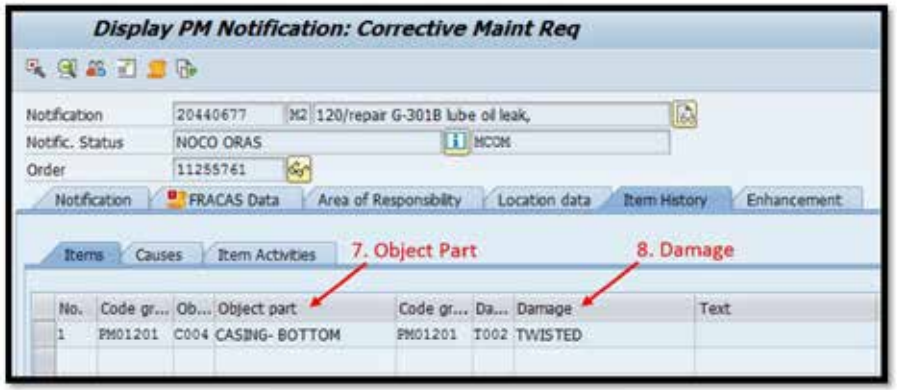
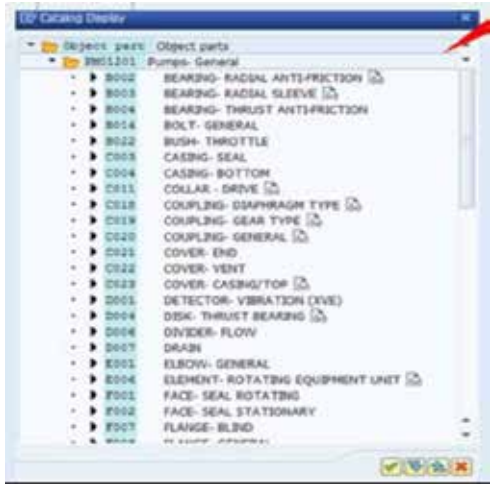


Figure [1-B] – Fields Evaluated in SAP



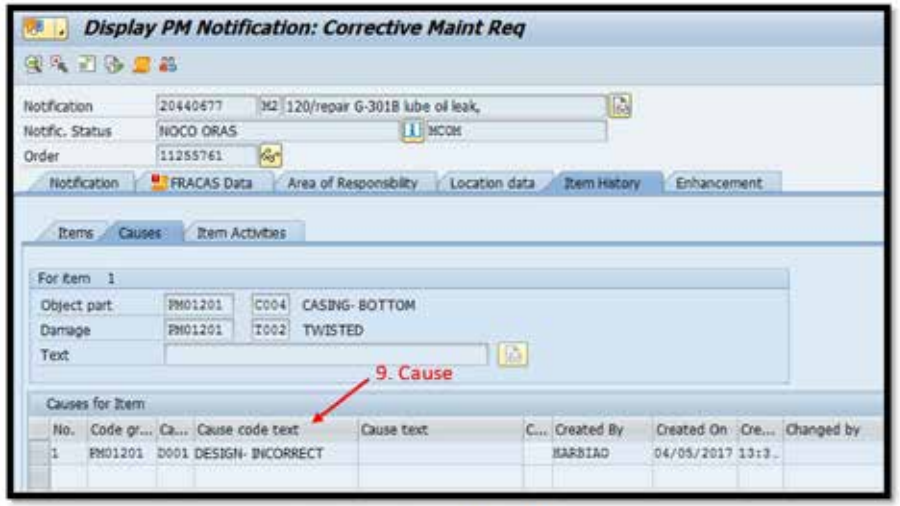
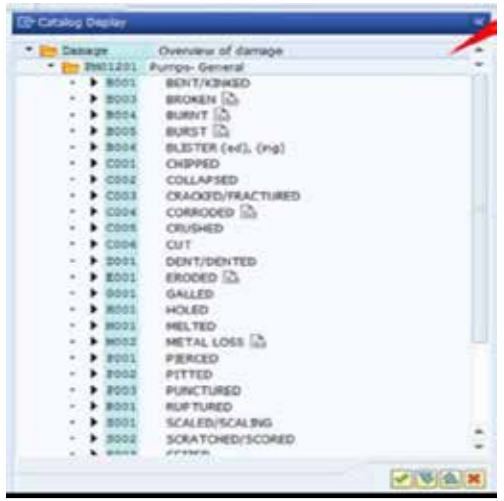


Figure [1-C] – Fields Evaluated in SAP



Site Data

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

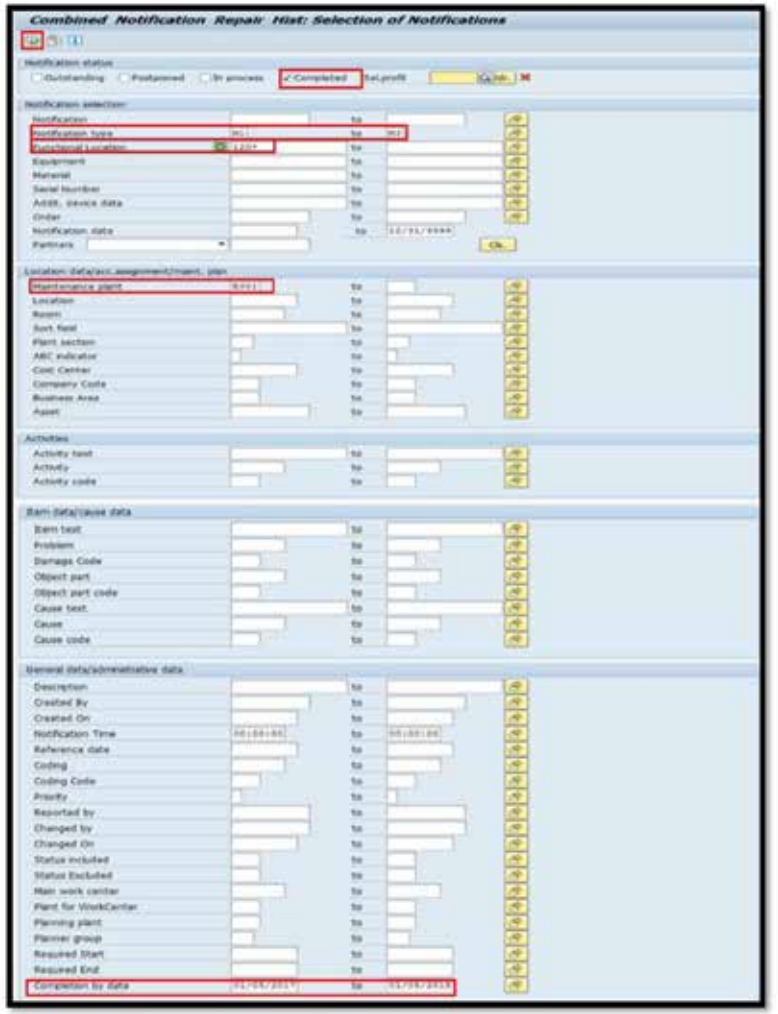


Figure [4] – ZI0110 SAP Screen

Site Data

Combined Notification Repair Hist: List of Notifications

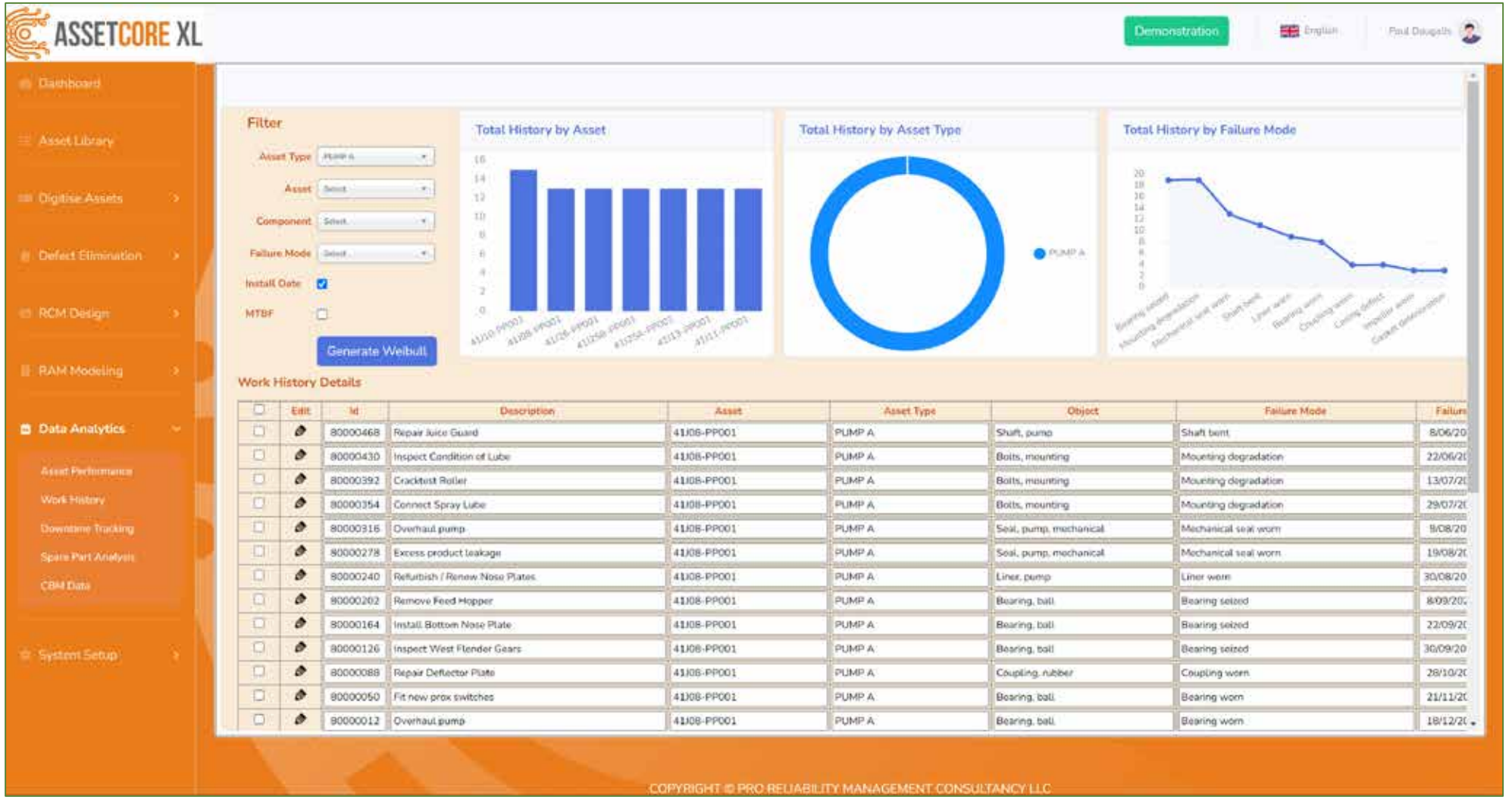
Notification | Long Text

S	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	cancelled	cancelled		
	11251314	10/29/2017	120/PIB-12 to verify VMS materials	work canceled.	work canceled.	PM011	PM011	K001	K001					canceled	cancelled
	11251315	10/29/2017	120/PIB-13 to verify VMS materials	cancelled	cancelled	PM011	PM011	K001	K001					canceled	cancelled
	11251315	10/29/2017	120/PIB-13 to verify VMS materials	cancelled	cancelled	PM011	PM011	K001	K001	PM011	PM011	cancelled	cancelled		
	11267264	12/24/2017	120/GT-9 chest valve replacement												
	20416646	05/30/2016	120/COL-16 AIT2117 NEED CALIPRATI			PM011	PM011	A002	A002	PM011	PM011	CALIBRATION (adjust	CALIBRATION (adjust		
	20416646	05/30/2016	120/COL-16 AIT2117 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-PMDR			PM01220	PM01220	S033	S033						
	20416695	05/30/2016	120/MOV1253 NOT WORKING-PMDR			PM01220	PM01220	S033	S033	PM01220	PM01220				
	20417283	06/05/2016	120/EM302D1 NOT WORKING -PMDR			PM01202	PM01202	S027	S027						
	20417283	06/05/2016	120/EM302D1 NOT WORKING -PMDR			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 attatch_	see attatch_
	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 attatch_	see attatch

Figure [5] – SAP ZI0110 Report

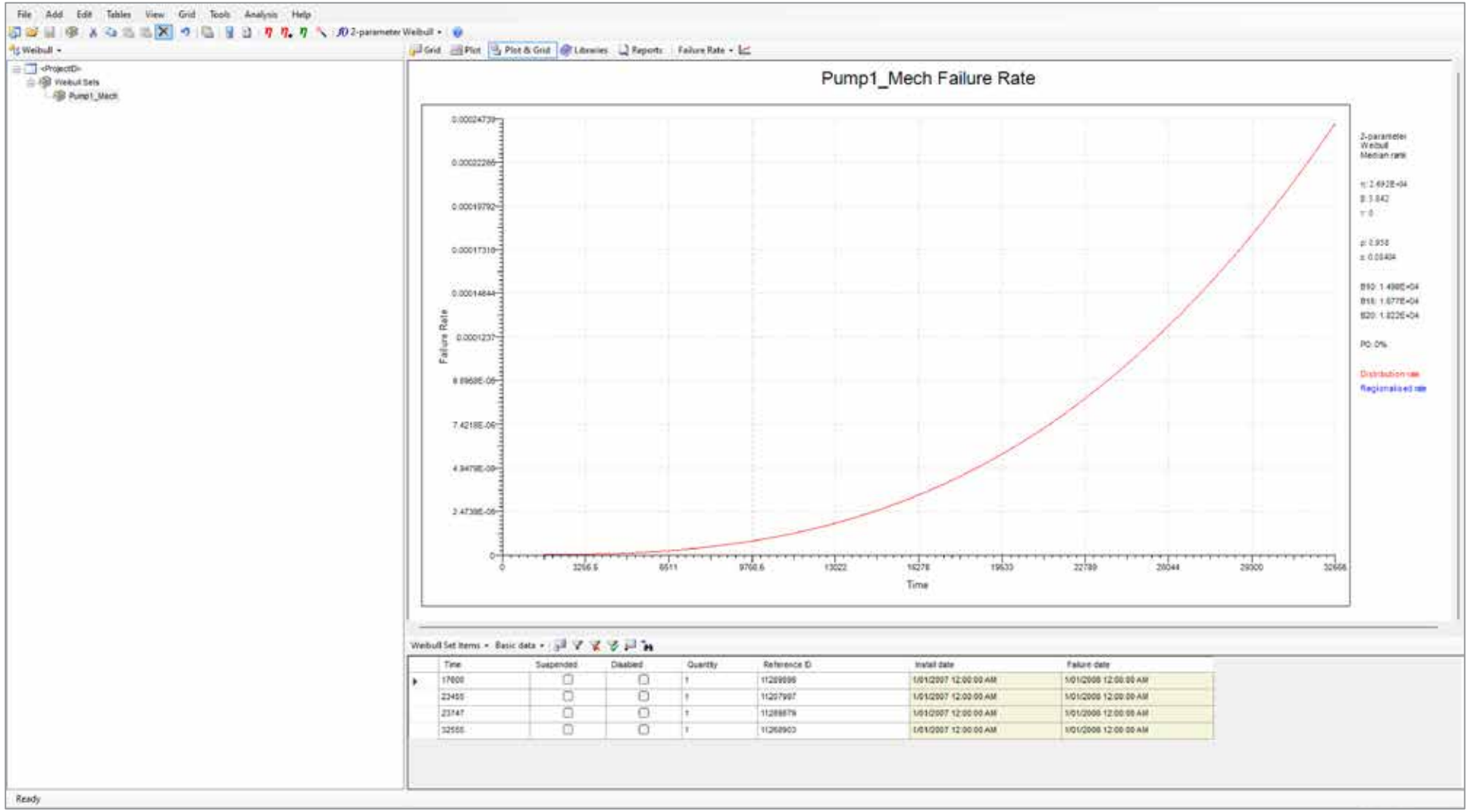
Site Data

DATA ANALYTICS



Site Data

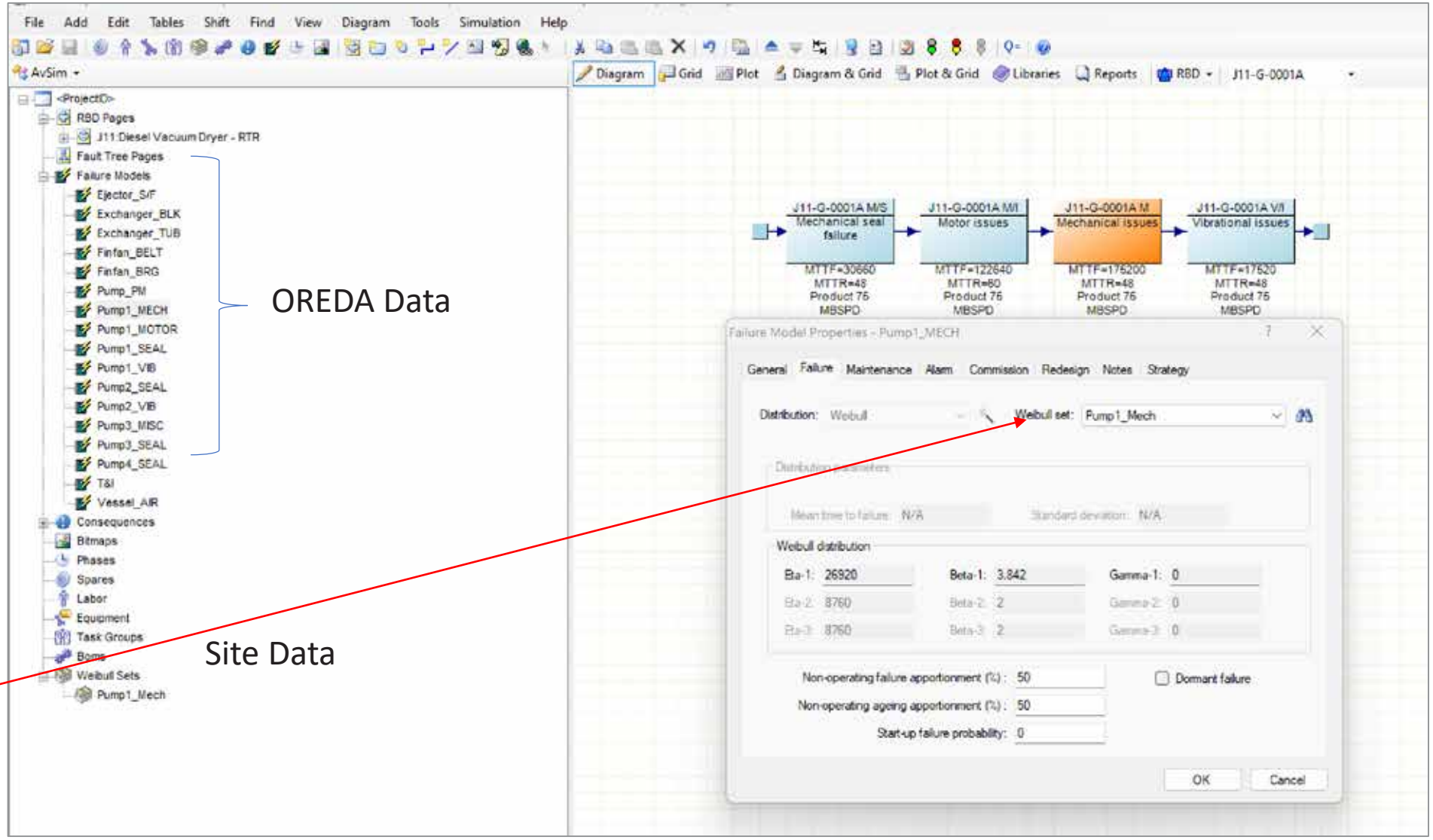
WEIBULL SETS



Site Data

WEIBULL SETS

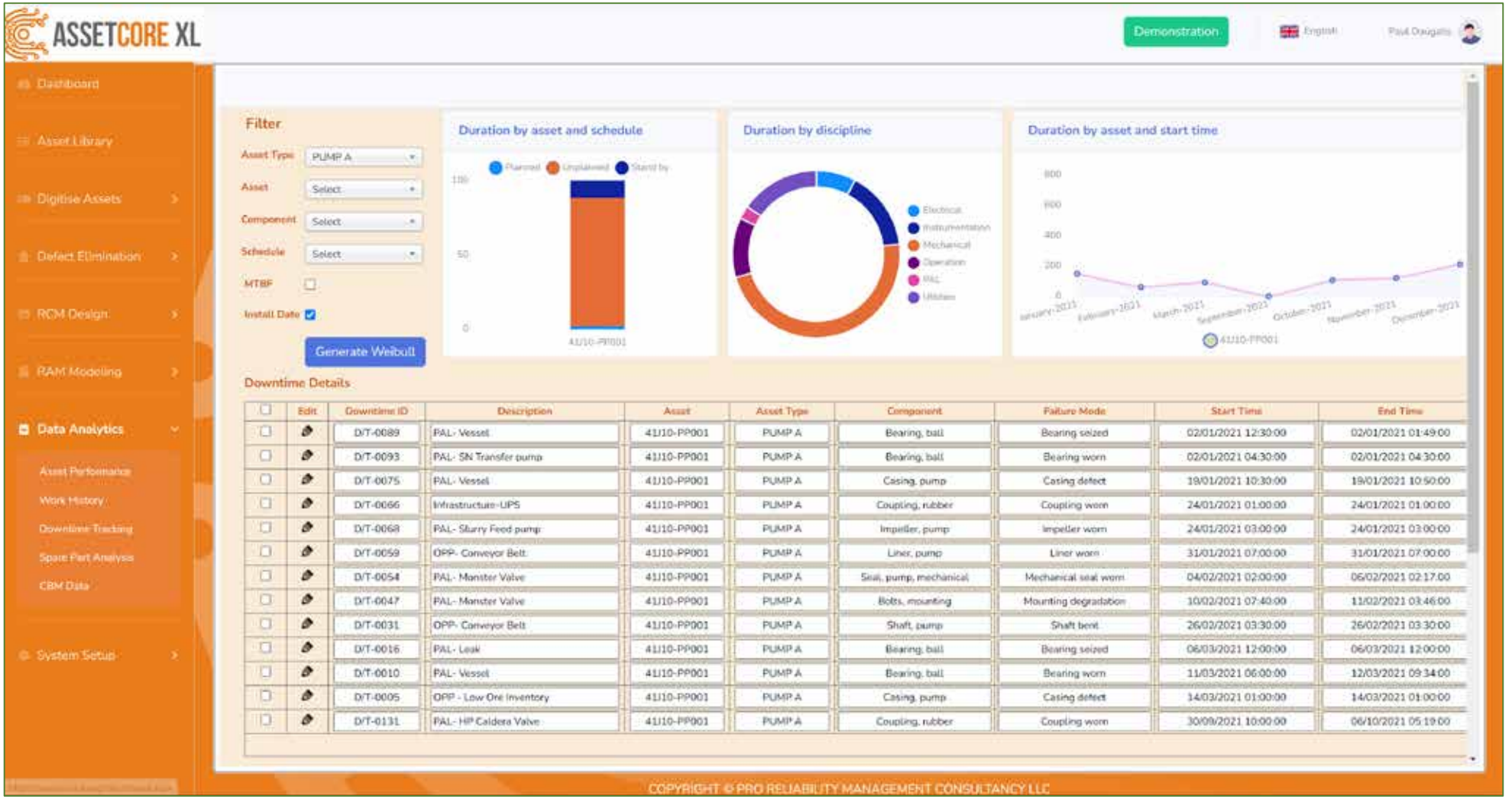
OREDA data is replaced over time with site data from SAP Notification history



#OmaintecConf

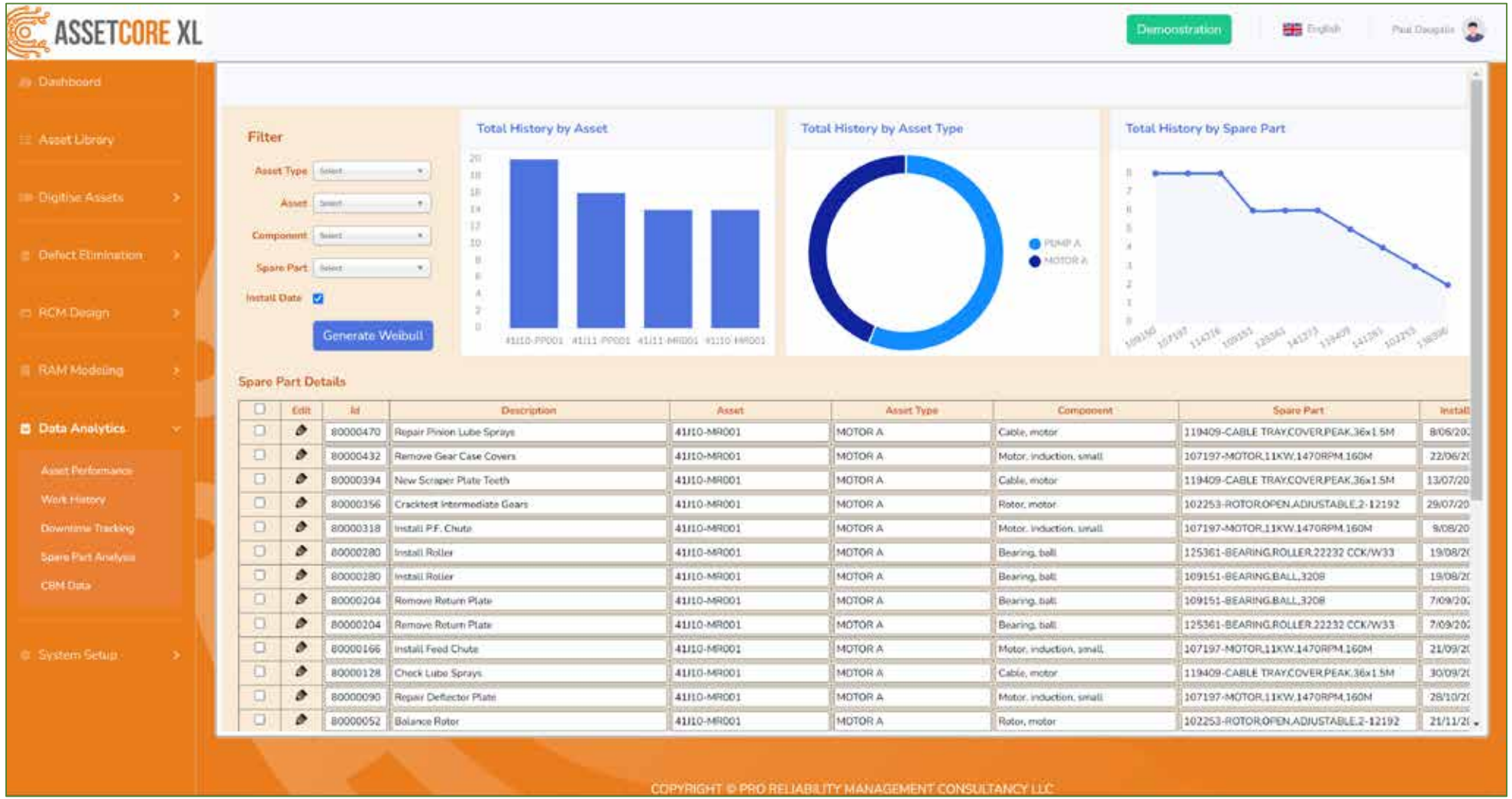
Site Data

DOWNTIME DATA



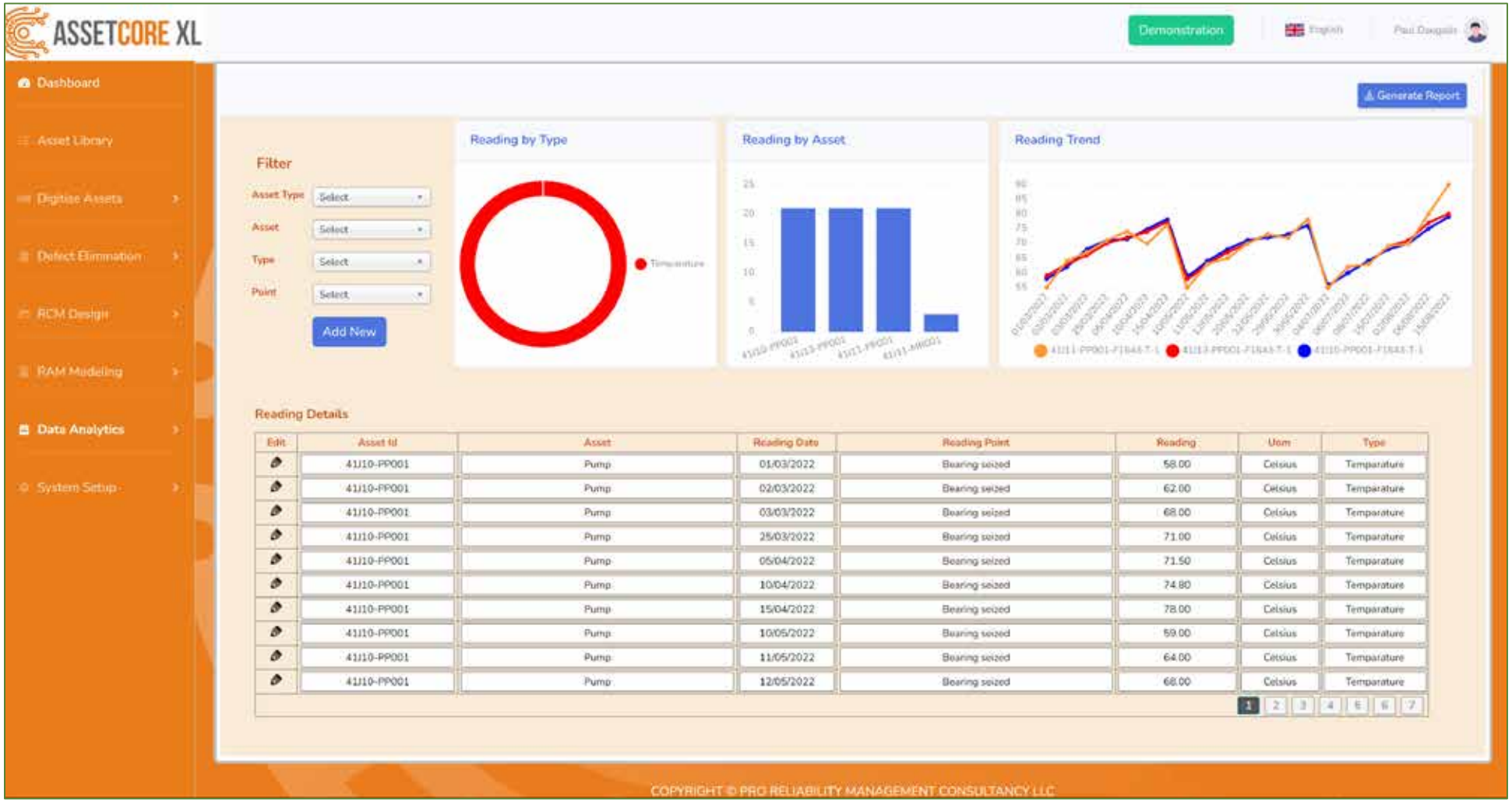
Site Data

SPARE PART USAGE



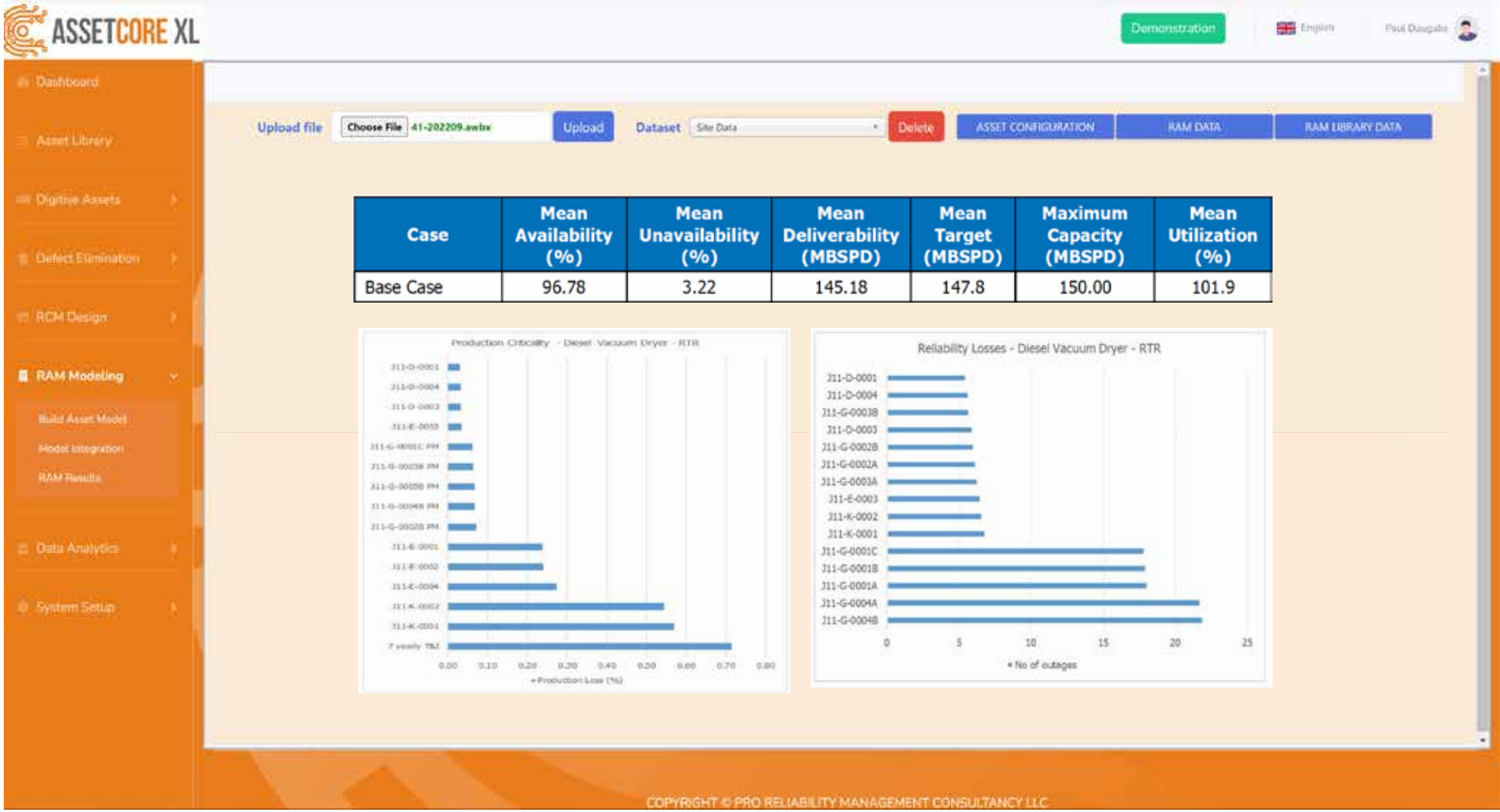
Site Data

CONDITION MONITORING DATA



AssetCoreXL Reporting

ONLINE RAM RESULTS



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

AssetCoreXL Reporting

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

SAES-A-030 Appendix A

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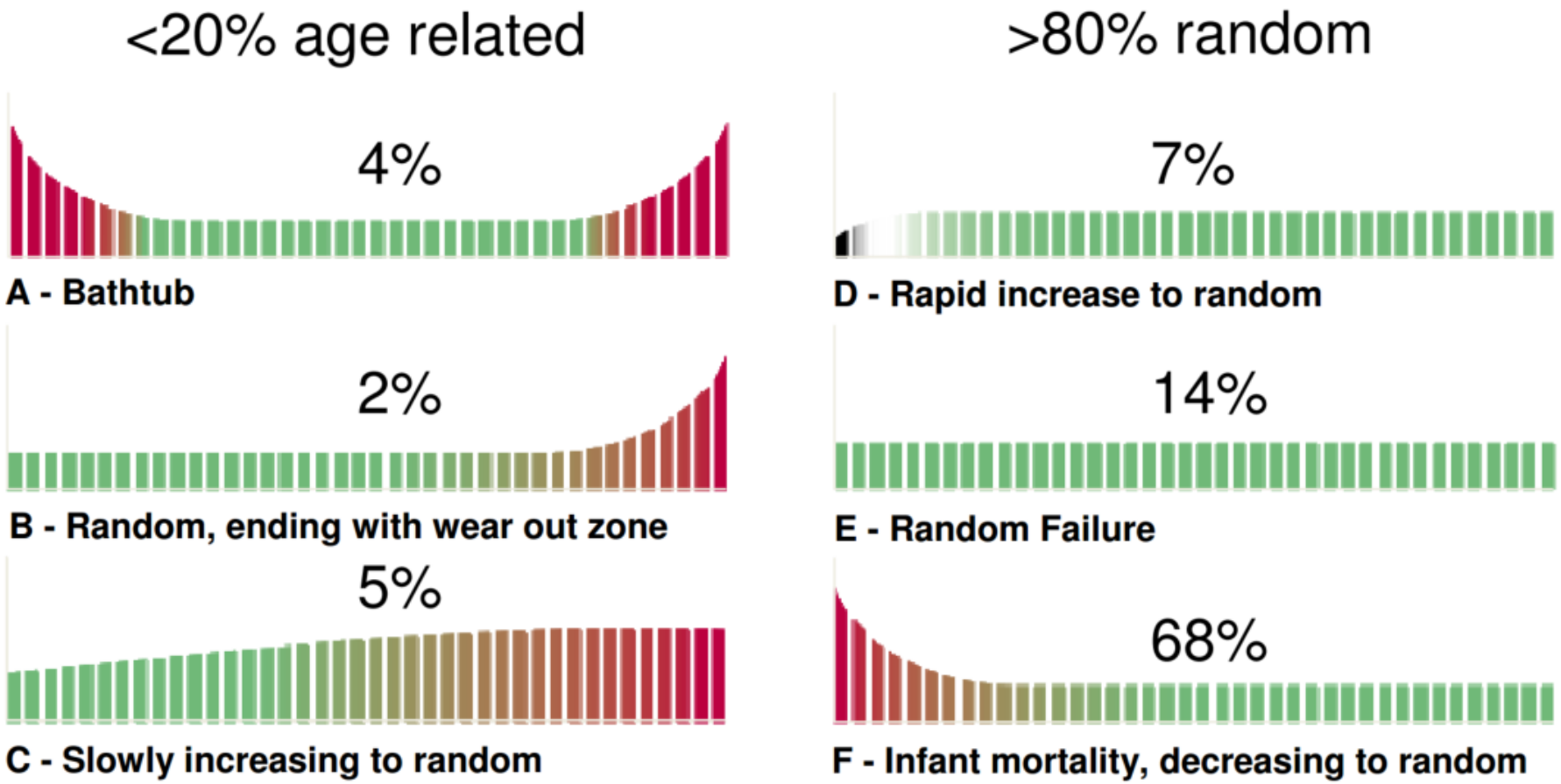
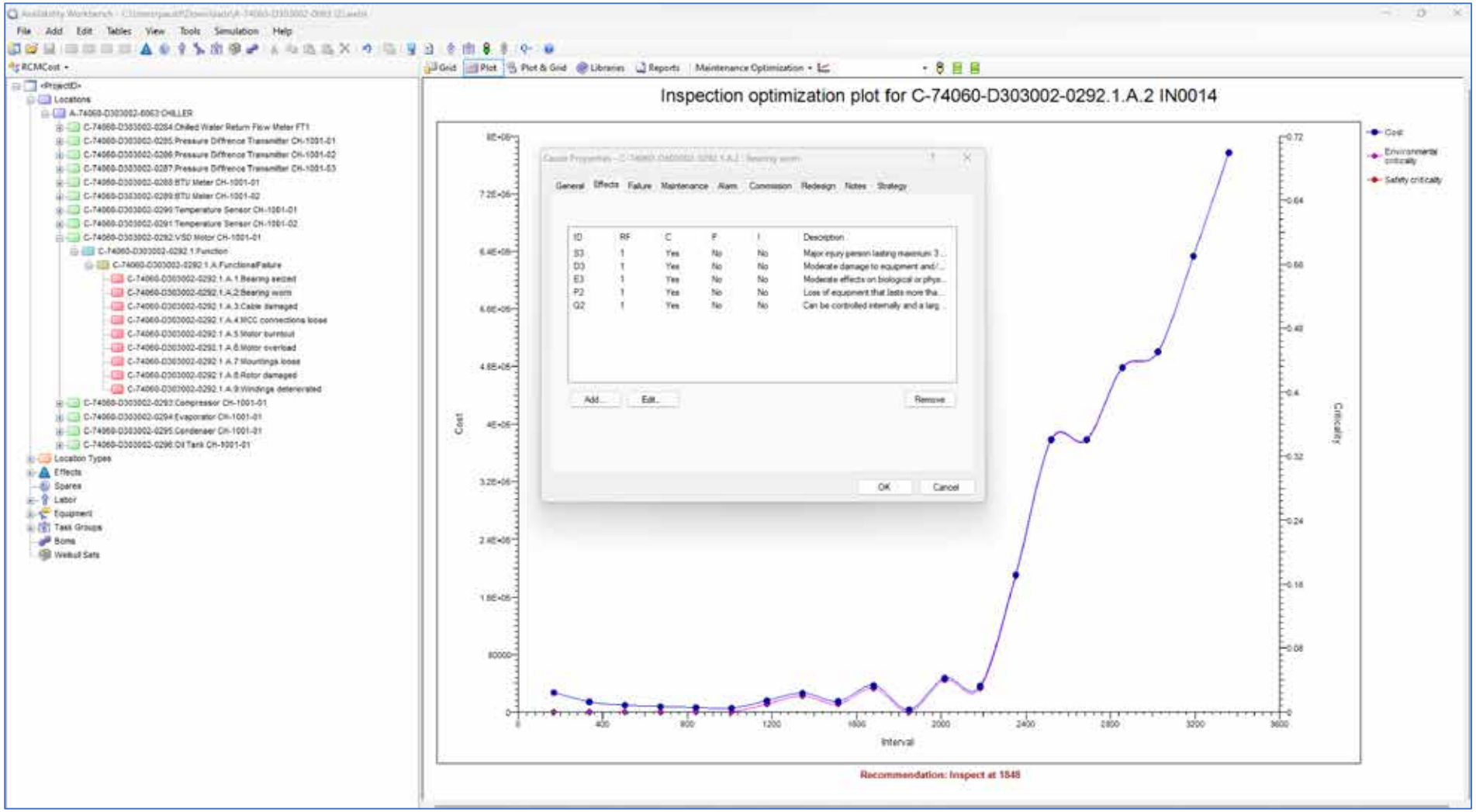
#OmaintecConf

Evaluate RCM Decisions Against Production Targets

RCM Principles



RCM Principles



Site Data

Failure mode:

CASING-BOTTOM
TWISTED CAUSED BY
DESIGN_INCORRECT

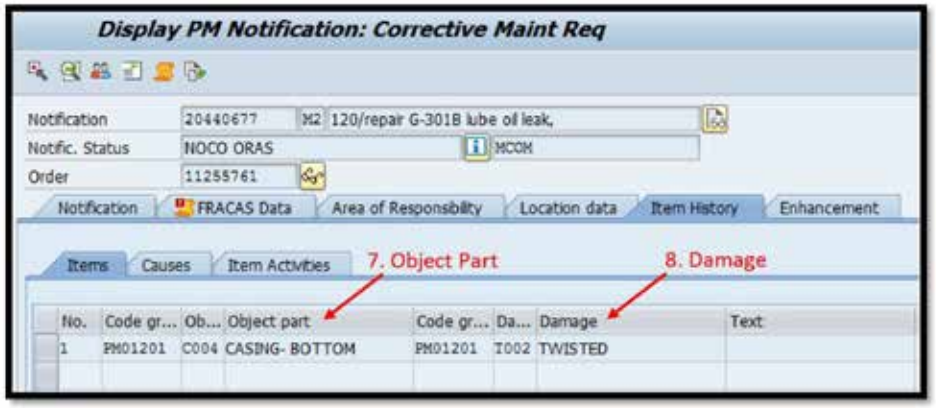


Figure [1-B] – Fields Evaluated in SAP

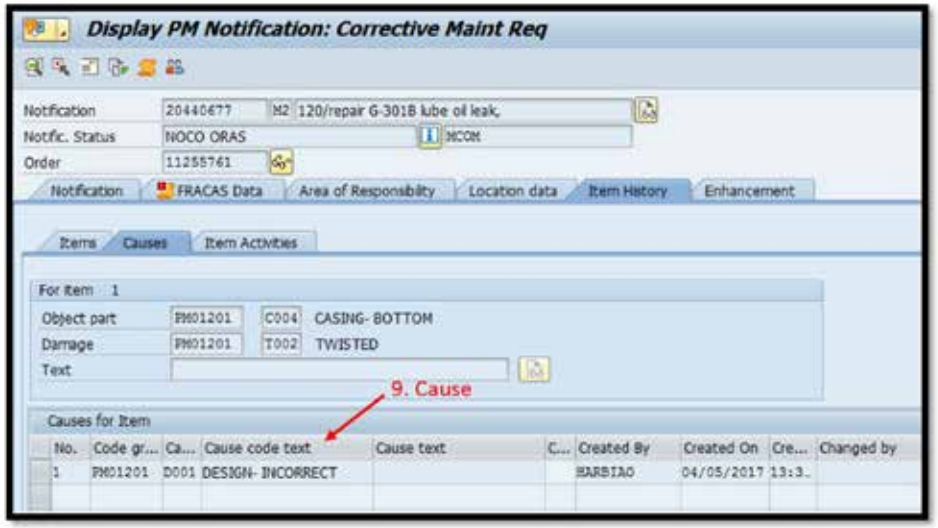
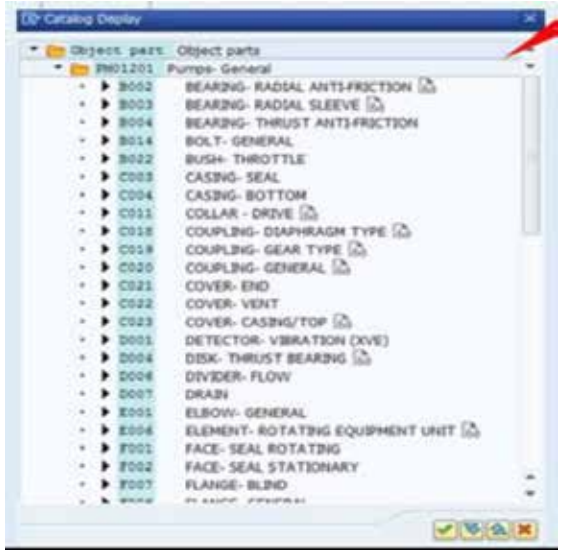
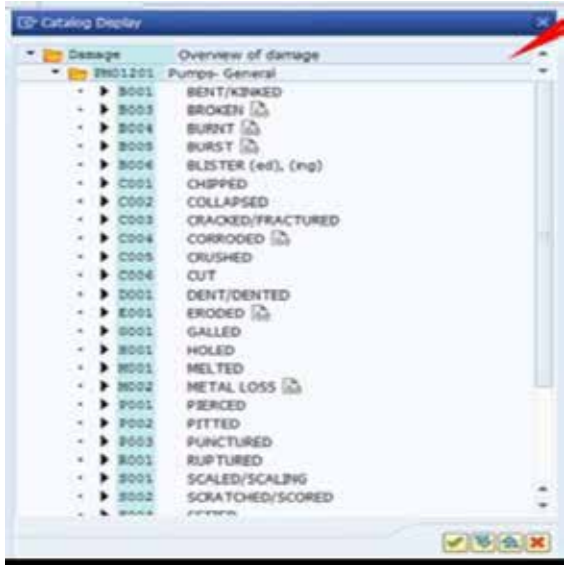
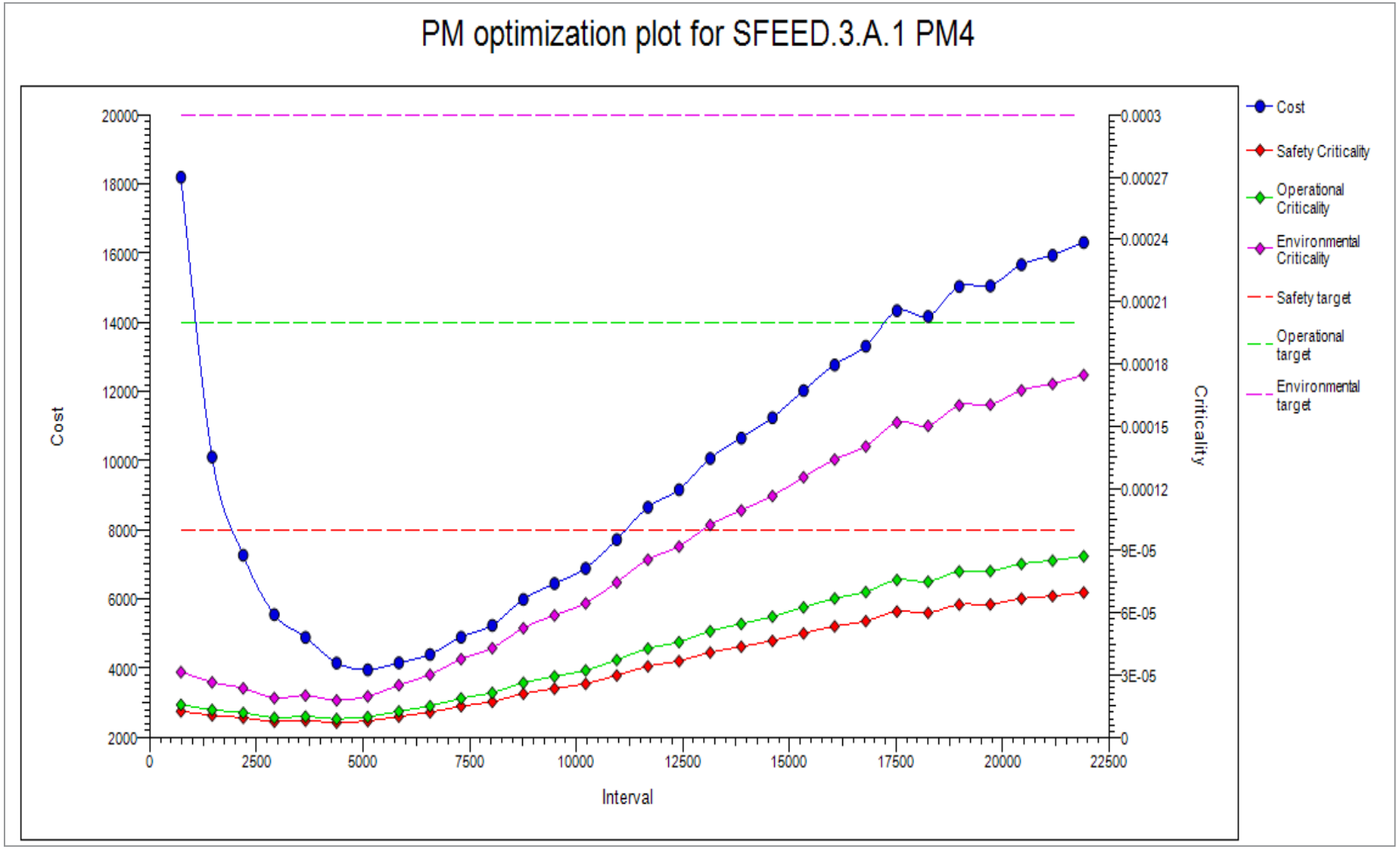


Figure [1-C] – Fields Evaluated in SAP

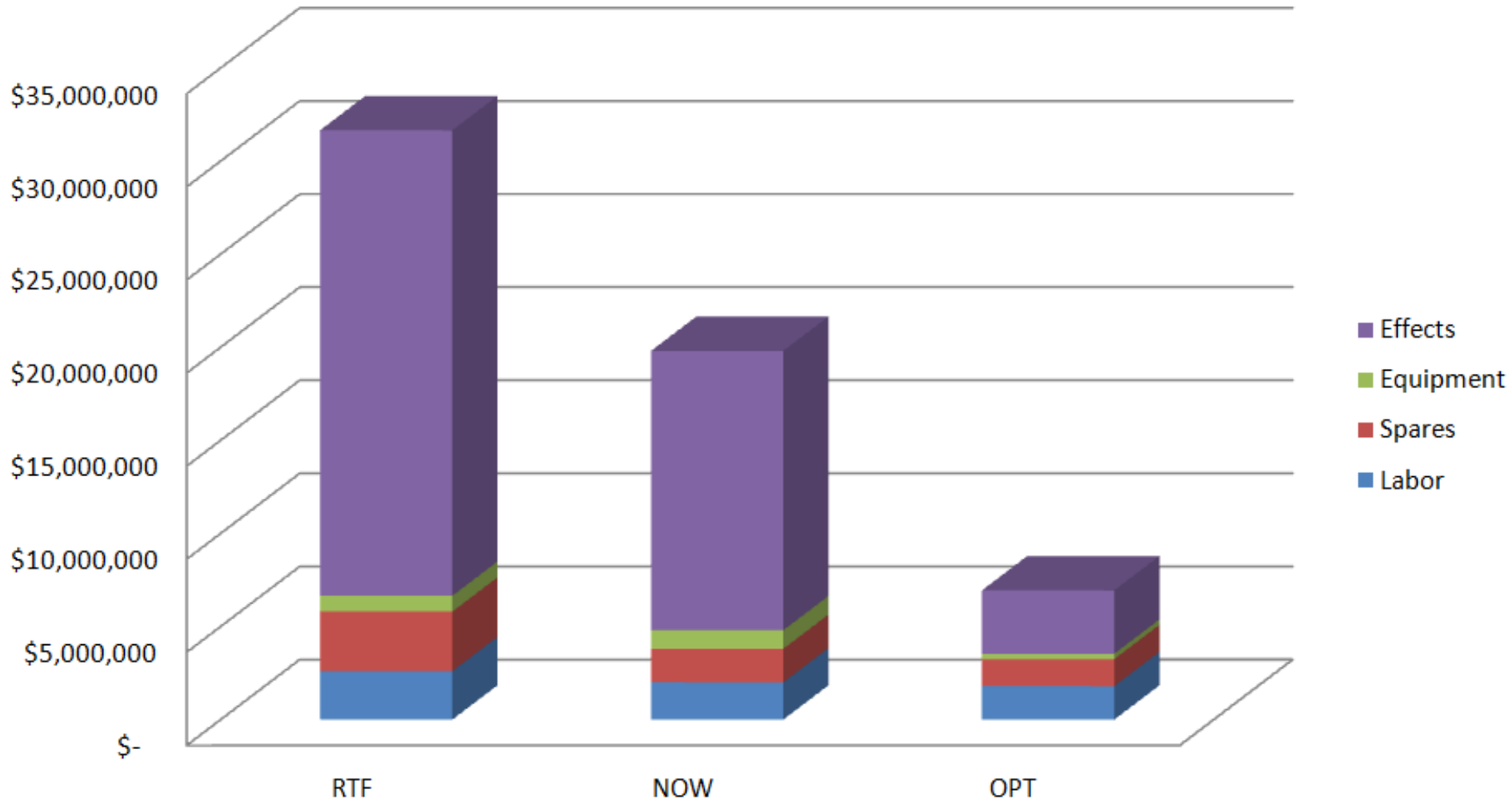




Optimisation

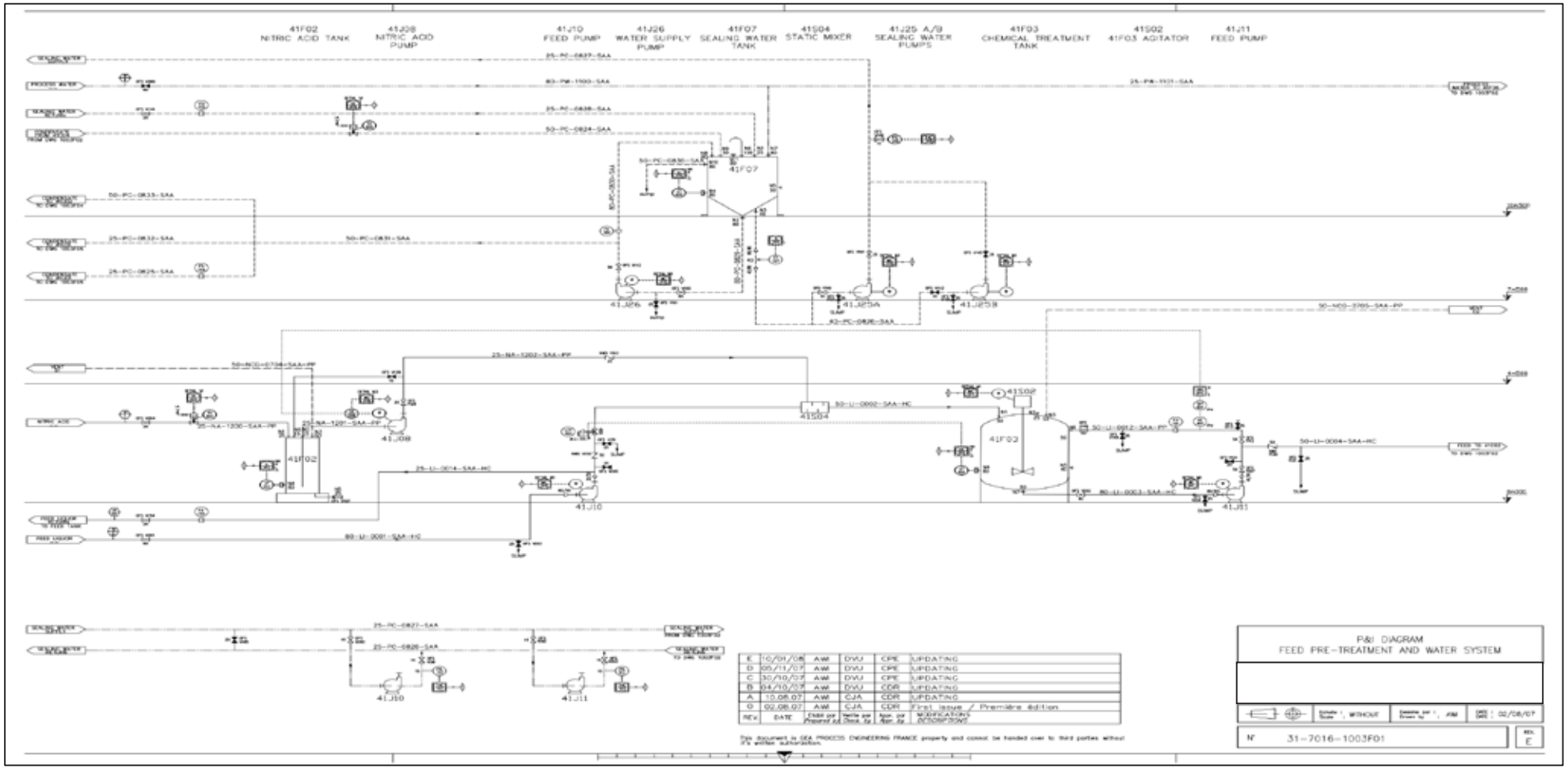


Sensitivity Cases

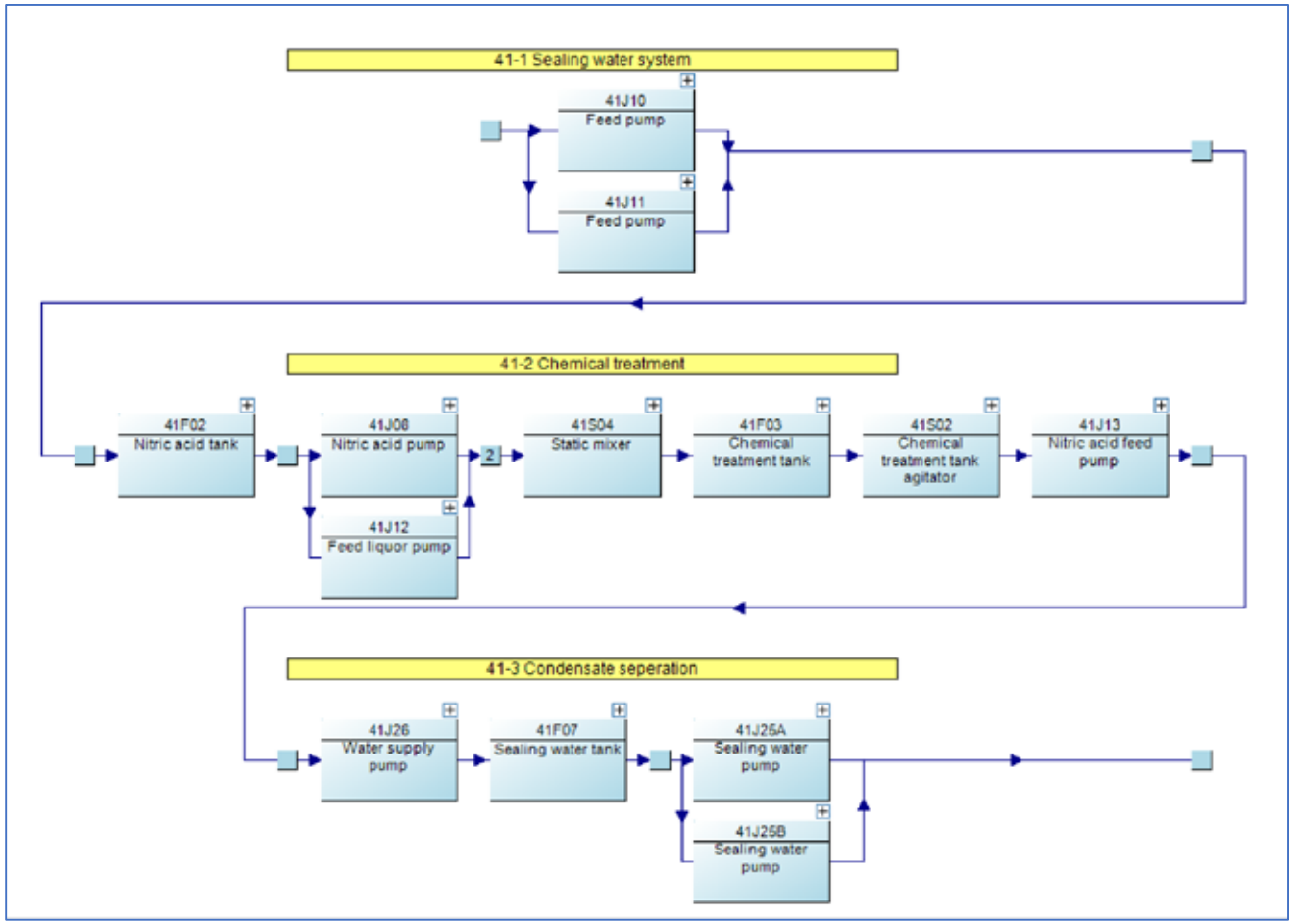


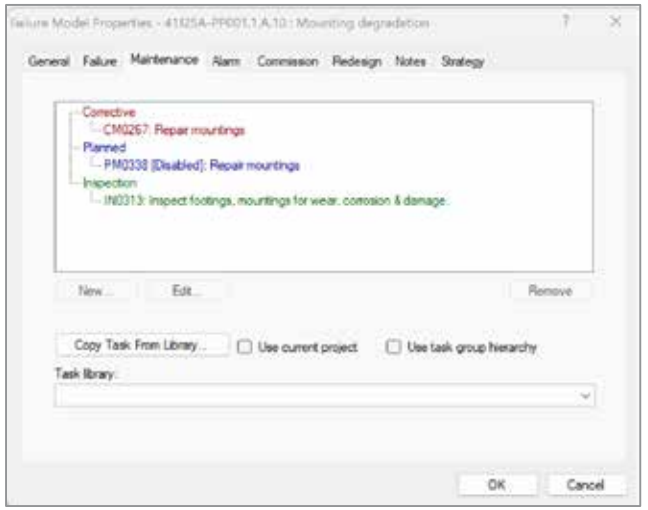
Sensitivity Cases

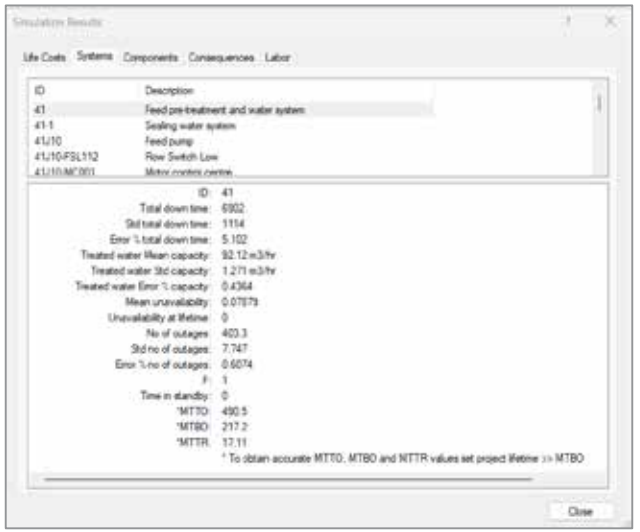
FEED PRE-TREATMENT & WATER SYSTEM



Sensitivity Cases







Sensitivity Cases

CURRENT AND OPTIMISED MAINTENANCE STRATEGIES

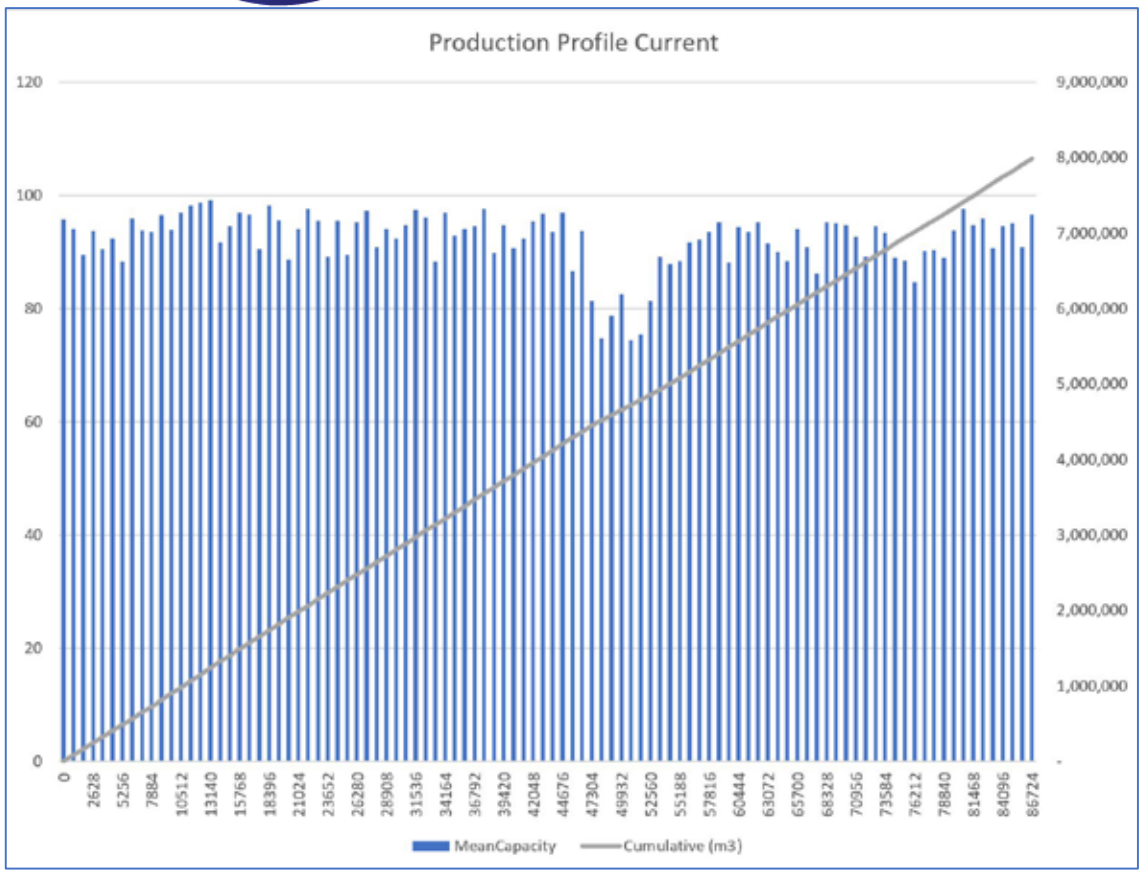
Asset	Task	Interval	Duration	Trade
41F02-TK001	Check the integrity of any earth or ground system cabling	8760	0.1	MEC(1)
41F02-TK001	Check condition of any manholes and clean out doors.	8760	0.2	MEC(1)
41F02-TK001	Visual inspection of the tank and shell of any distortion	8760	0.2	MEC(1)
41F02-TK001	Inspect 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)

ME1Y ANNUAL MECHANICAL PREVENTIVE MAINTENANCE (CURRENT)

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)

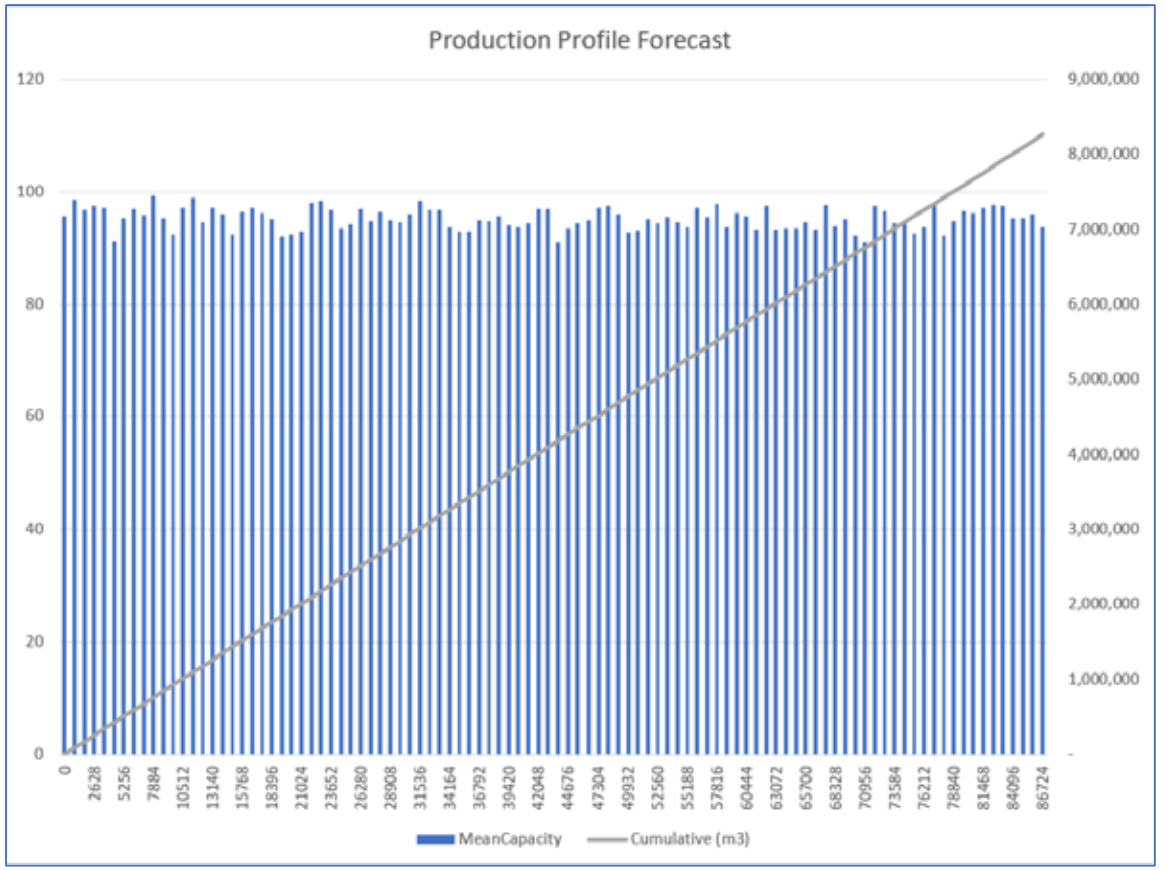
AFTER OPTIMISATION

Sensitivity Cases



7,985,103 m³

TOTAL m³ (CURRENT)



8,265,061 m³

TOTAL m³ (FORECAST)

3.51%

279,958 m³

ADDITIONAL PRODUCT

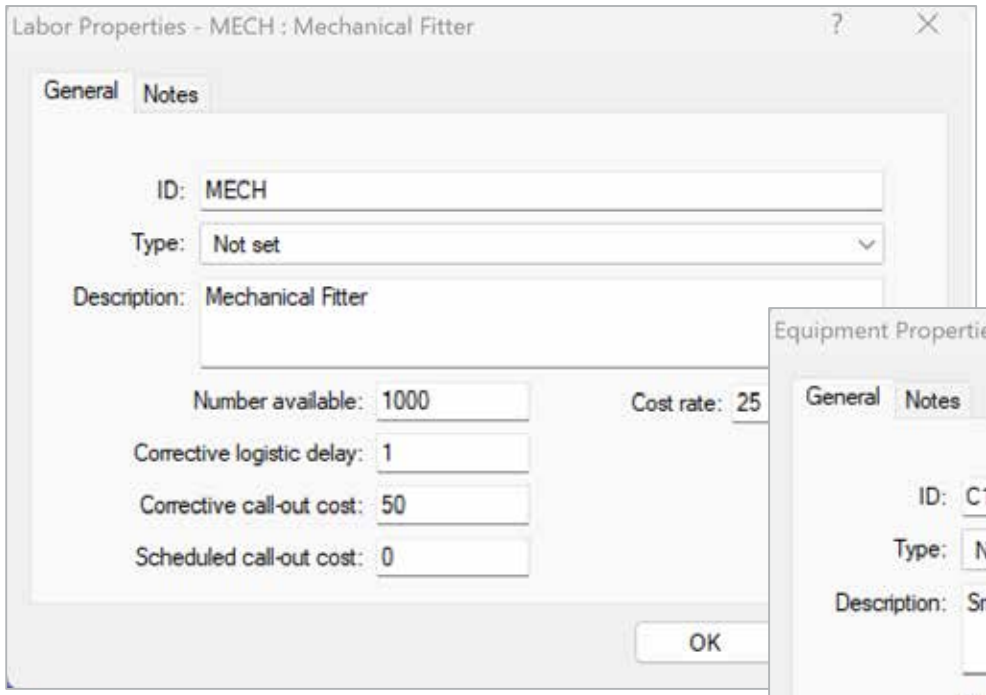
RBD with strategy 1 and 2 with system profile in production units m3/hr

Maintenance Budgeting & NPV Calculations Over Asset Life

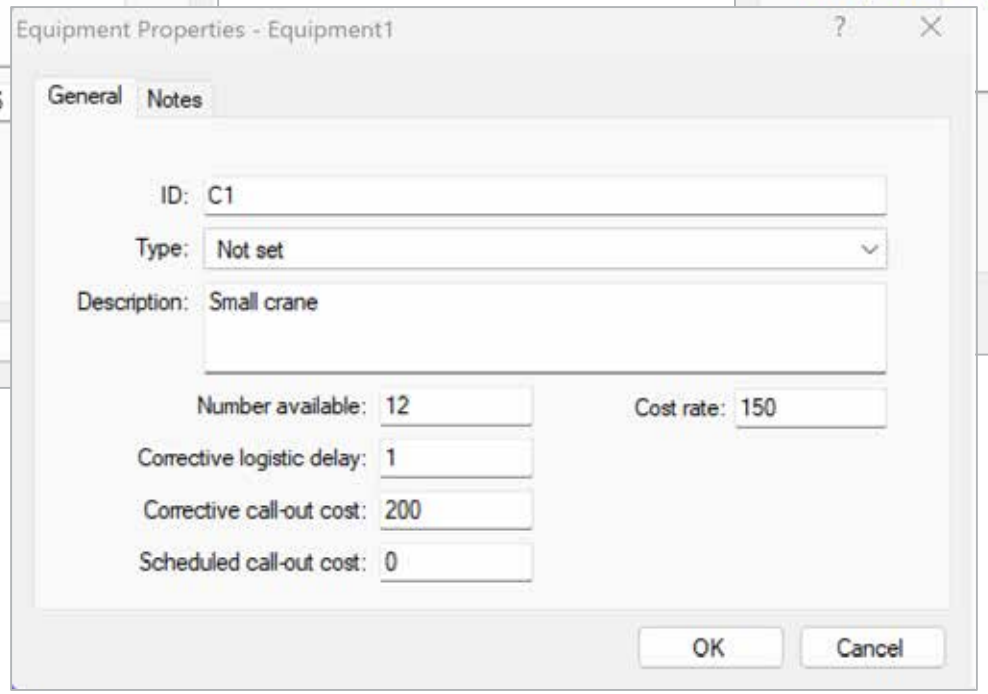
Maintenance Budget

- **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

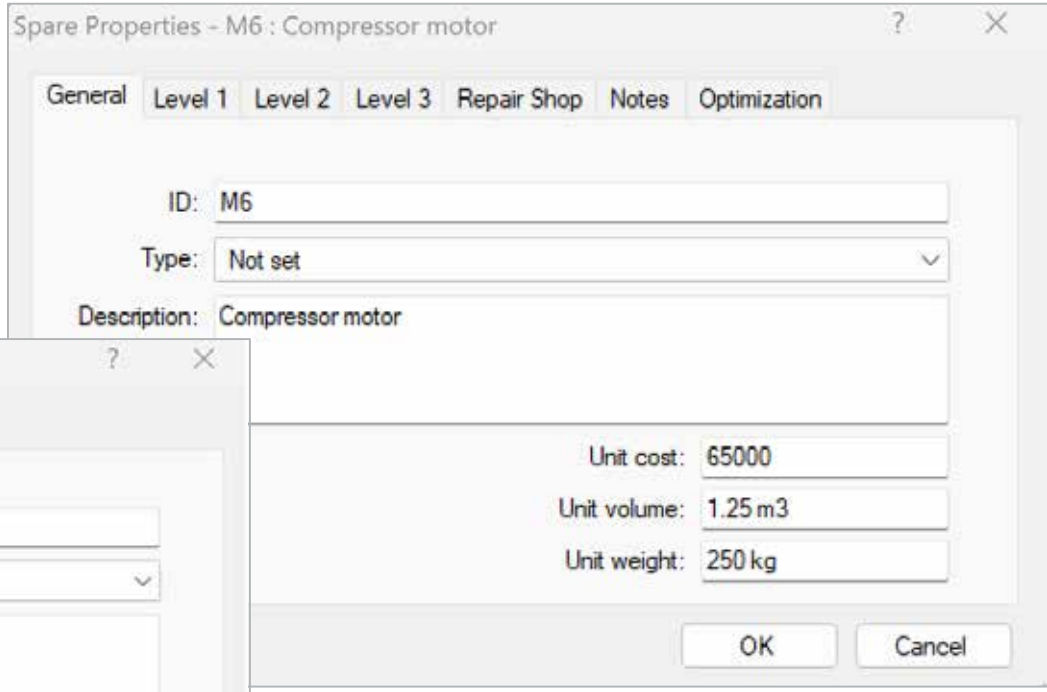
Maintenance Budget



LABOR SETUP

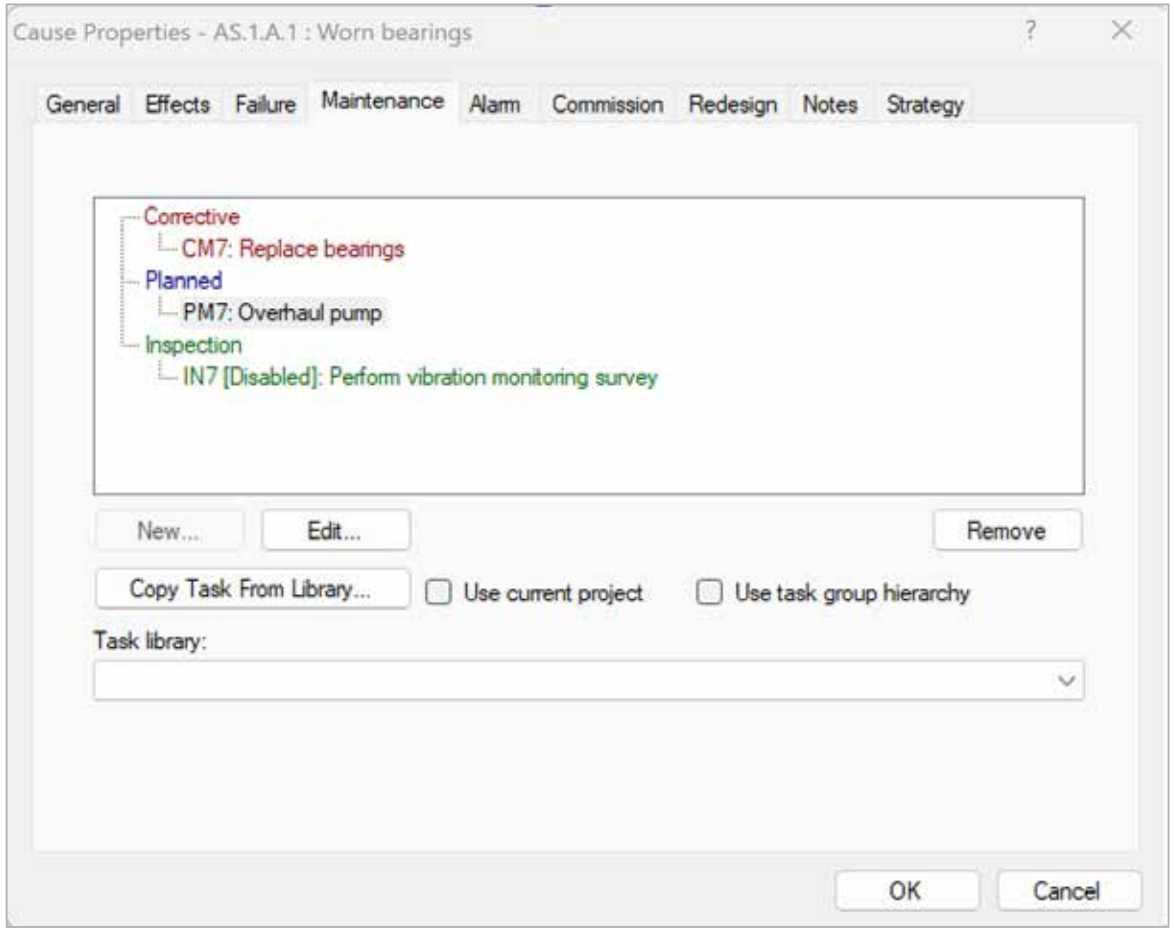


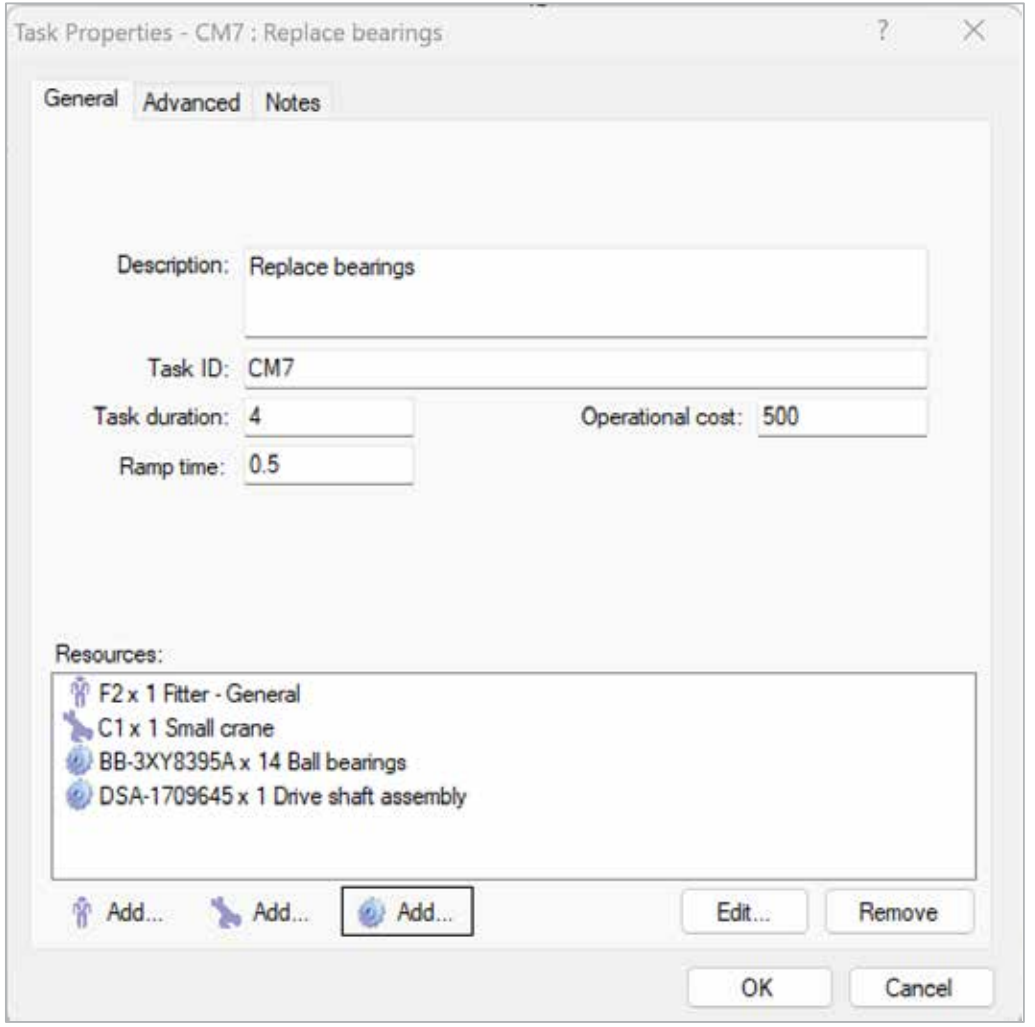
EQUIPMENT SETUP



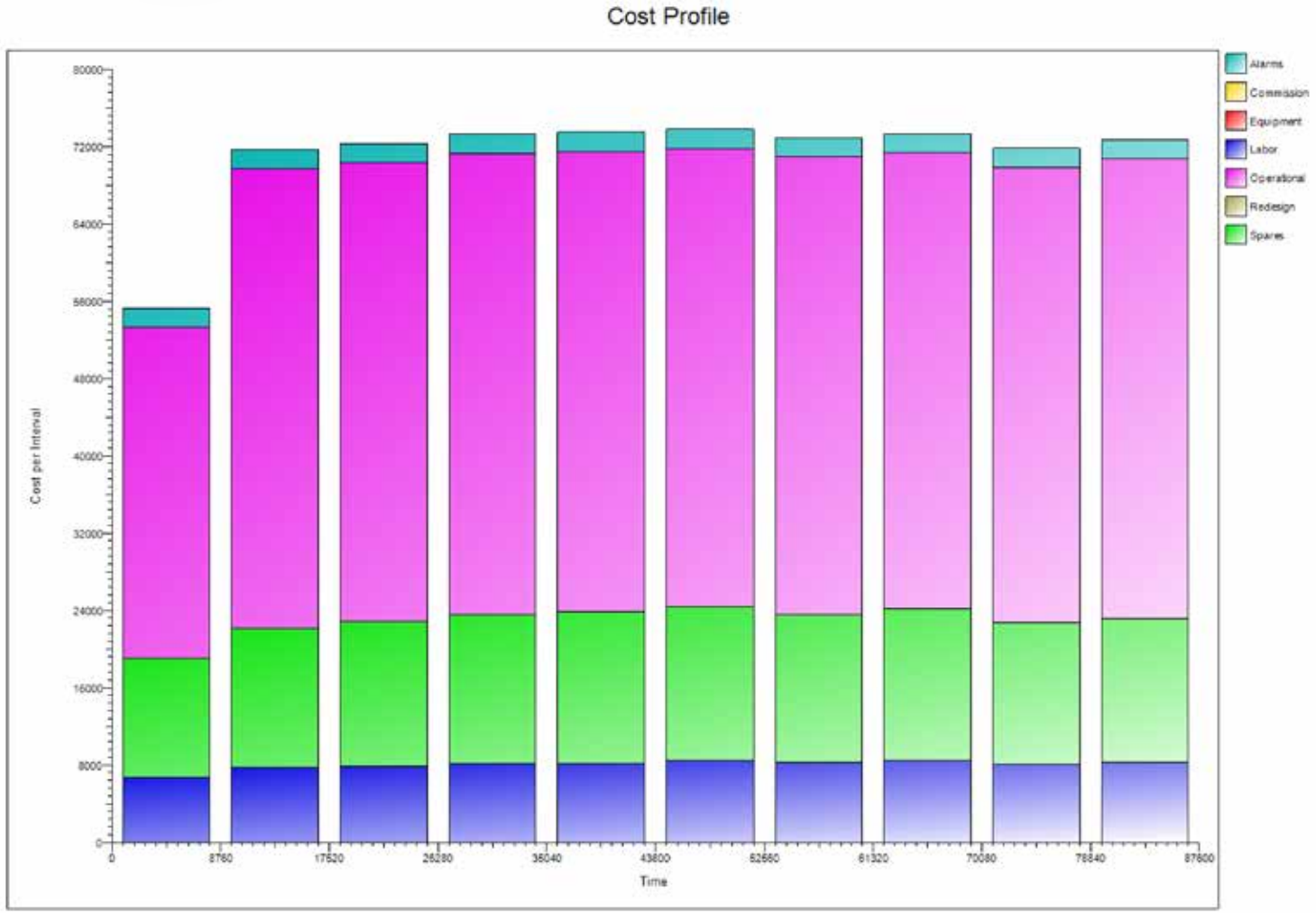
SPARE SETUP

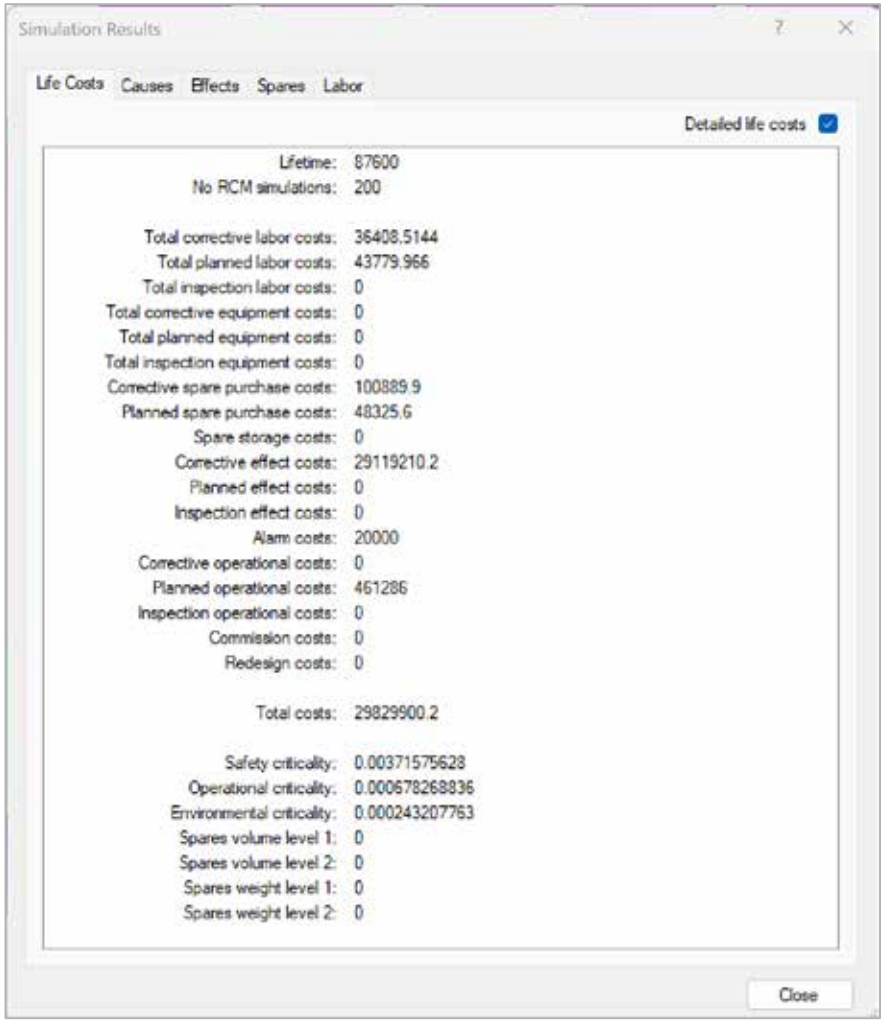
Maintenance Budget





Maintenance Budget





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%

NPV yield % per annum

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.

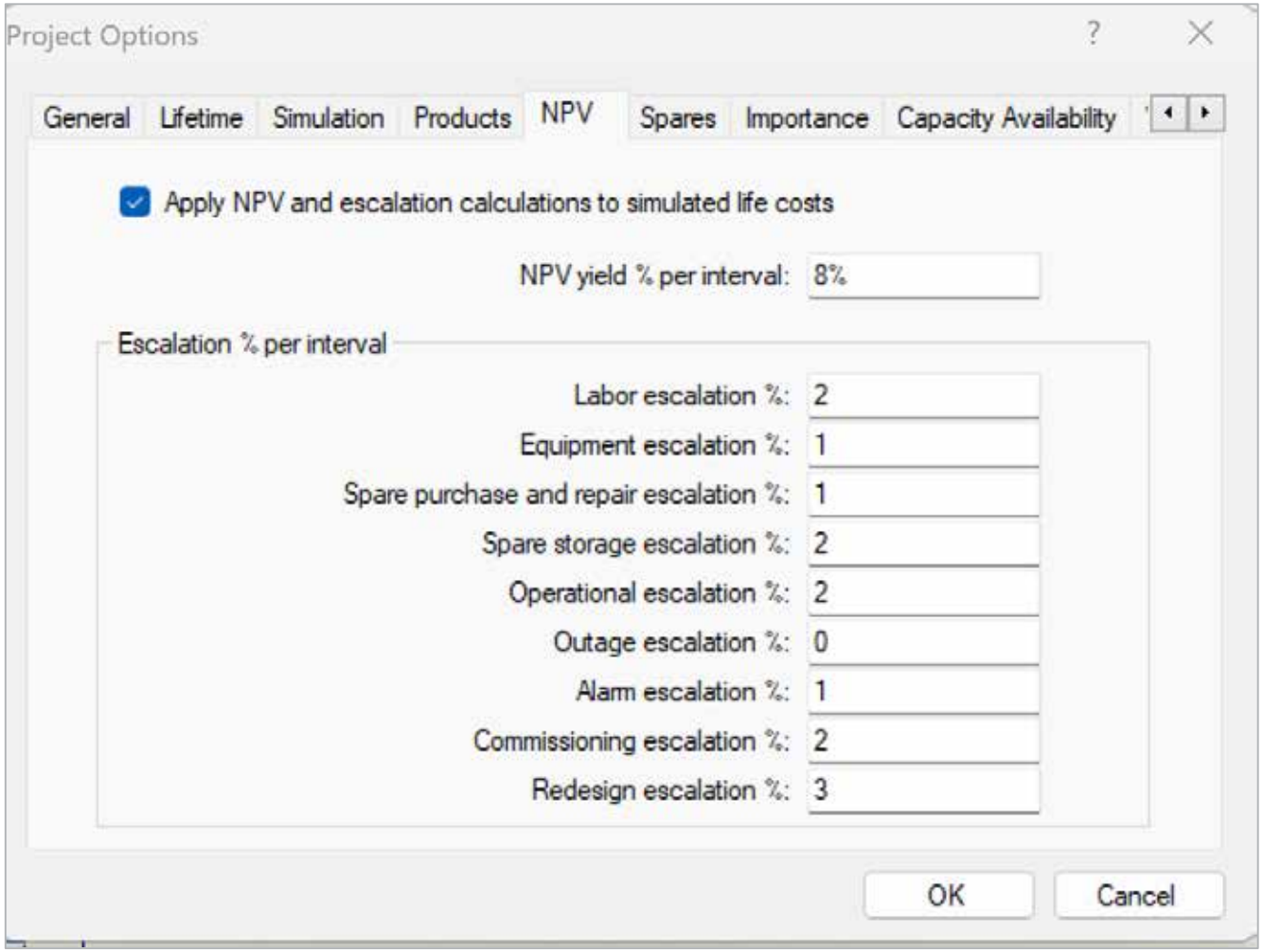
2.Equipment Escalation %: Equipment costs can vary widely based on technological changes, demand, and supply factors. A general range might be 1% to 5% per annum, with certain industries or technologies seeing occasional spikes due to breakthroughs or supply chain disruptions.

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.

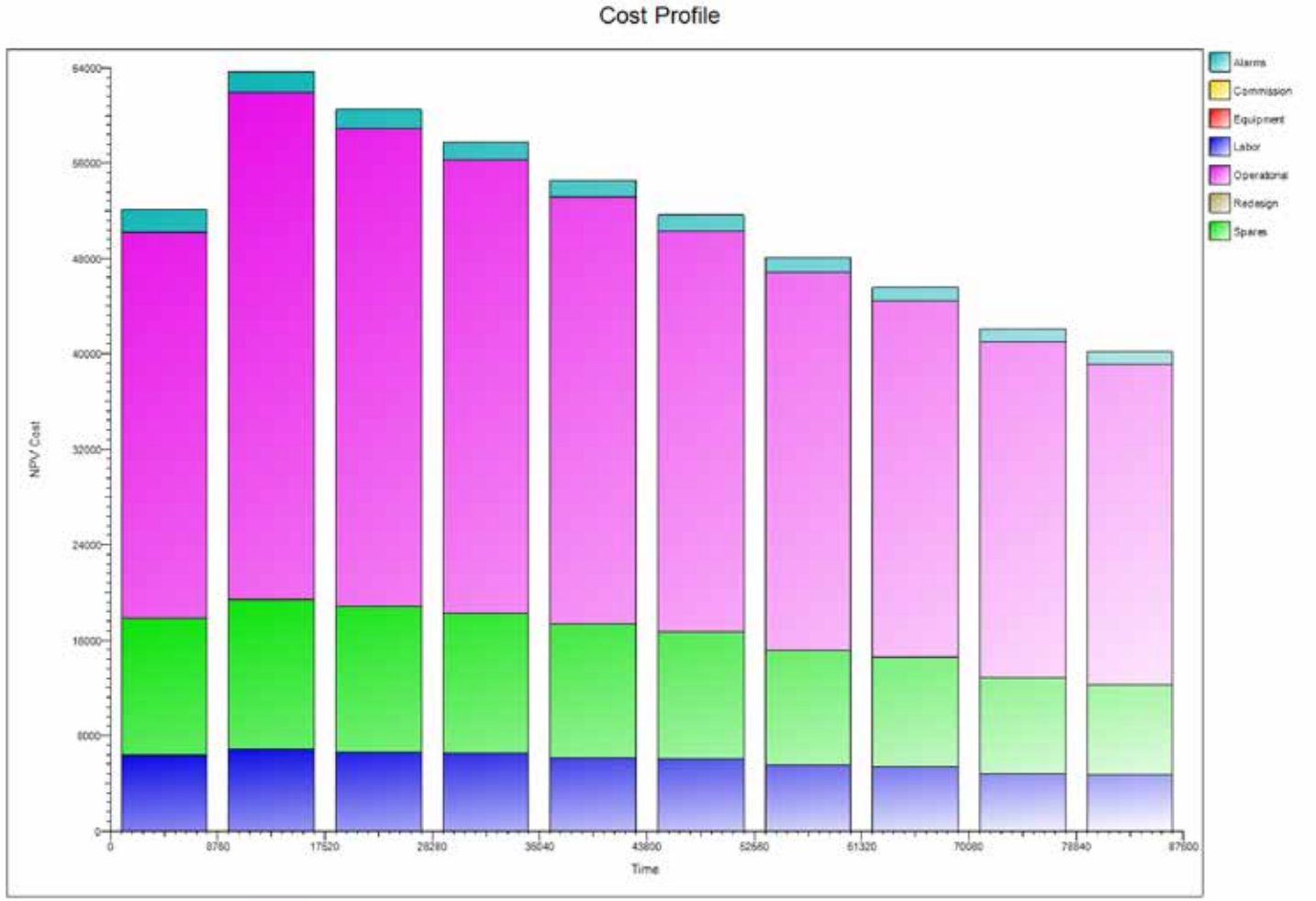
5. **Operational Escalation %:** Operational costs typically increase with inflation and additional regulatory or maintenance requirements. This might range between 2% and 7%.
6. **Outage Escalation %:** This would be industry-specific and harder to generalize. Outages, especially unplanned ones, can 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



SETUP NPV VALUES FOR SIMULTION

Net Present Value



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.

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