

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

Digital Twins Unveiled

Simulating Asset Performance for **Optimal Management**

⑦ ◎ ◎ ○ #OmaintecConf

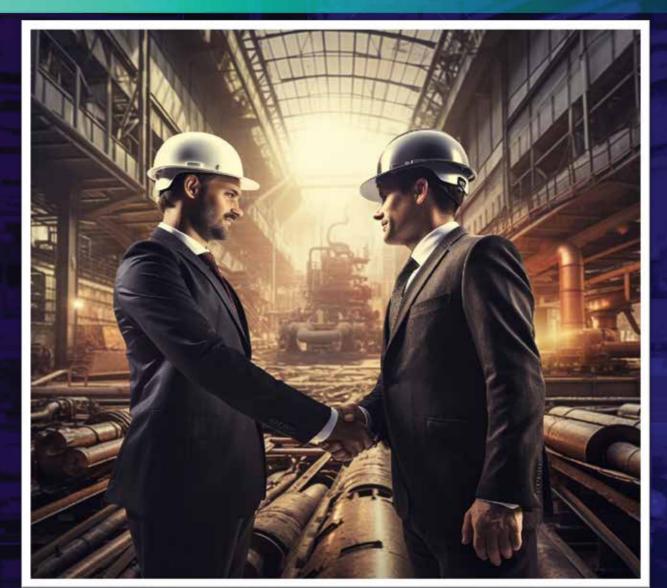
An Initiative by

Organized by





Introduction



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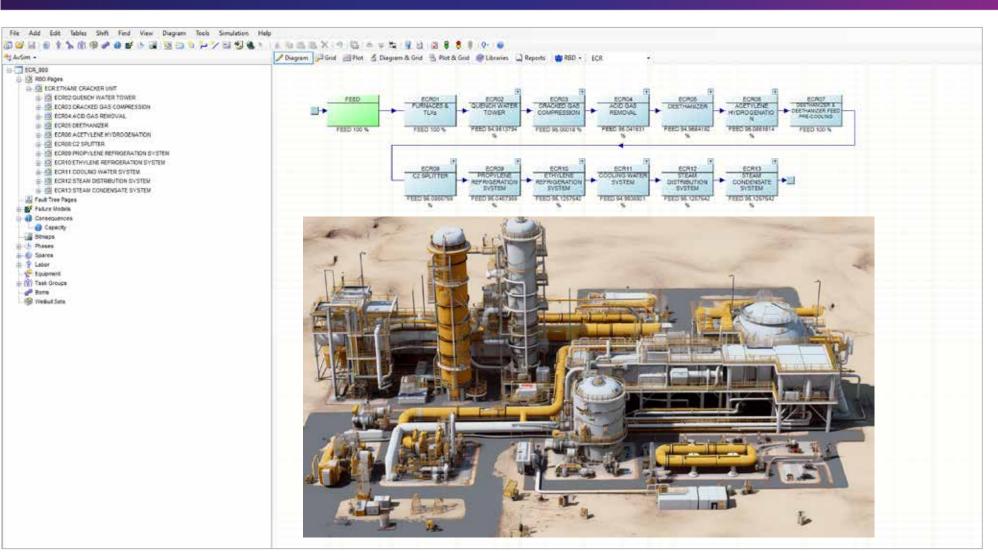


Paul Daugalis	 B.Eng (mech) University of South Australia (1994) Certified Maintenance and Reliability Practitioner (CMRP) Ex-Chairman European Asset Management Committee (EAMC) Chairman Lithuanian Technical Maintenance Engineering Association (LTPIA)
2021 to Now	AssetCoreXL – Managing Director (UAE), 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)
	Mackay Sugar Mackay Sugar Mackay Sugar Mackay Sugar Mackay Sugar Mackay Sugar Mackay Sugar Mackay Sugar Mackay Sugar MewMont MewMont MewMont MewMont MewMont MewMont MewMont MewMont MewMont MewMont Mackay

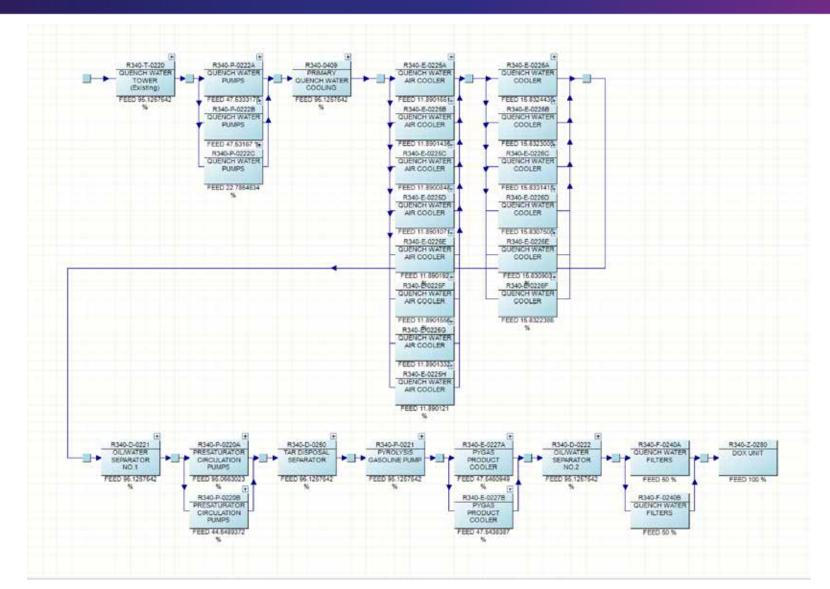






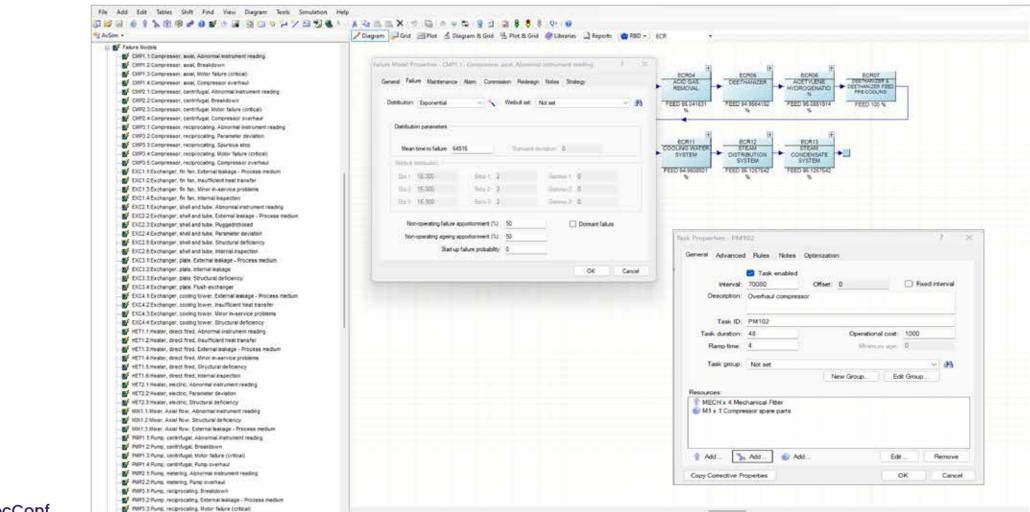








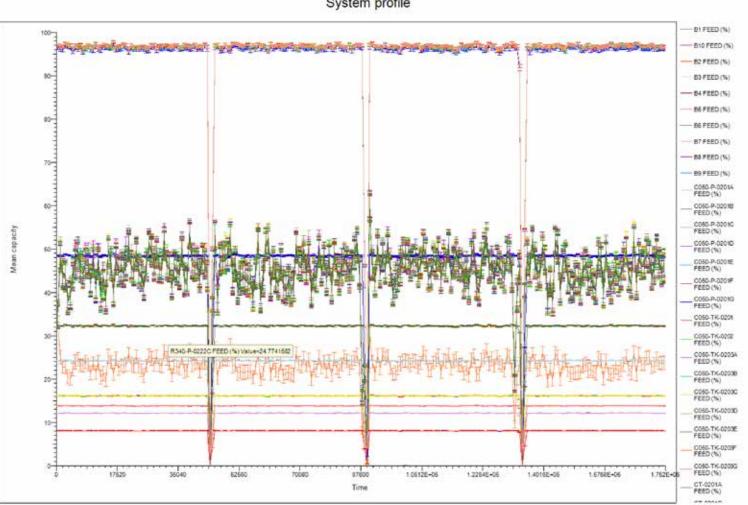
TEC Case Study





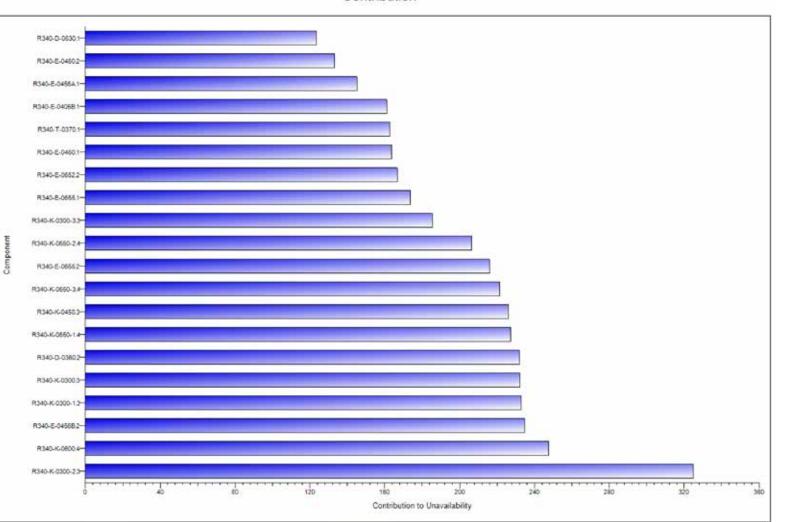
ife Costs	Systems	Components	Conse	quences	Phases	Spares	Labor						
ID		Descriptio	on										
ECR		ETHANE	CRACH	ER UNI	т								
ECR02		QUENCH	WATE	R TOWE	R								
ECR03		CRACKE	D GAS	COMPRE	ESSION								
ECR04		ACID GA	S REM	OVAL									
FCR05		DFFTHA	NIZER										
			ID:	ECR									
		Total down	n time:	8539.67	7864								
		Std total down	n time:	440.699	92								
	Er	ror % total dow	n time:	0.51606	5148								
	F	FEED Mean cap	oacity:	94.3933	305 %								
		FEED Std cap	oacity:	0.25744	5978 %								
	FE	EED Error % cap	oacity:	0.02727	37466								
		Mean unavail	ability:	0.04874	2458								
	Ur	navailability at lif	etime:	0.01									
		No of ou	tages:	382.58									
		Std no of ou	tages:	20.0614	955								
	E	Error % no of ou	tages:	0.52437	73868								
			F:	1									
		Time in sta	andby:	0									
		-1	ATTO:	423.270	695								
		-1	ITBO:	457.943	3437								
		-1	ATTR:	22.3212	2887								
				* To obt	ain accura	ate MTTO	, MTBO a	nd MTTR	values set pr	oject lifetir	ne >> MTI	BO	





System profile





Contribution



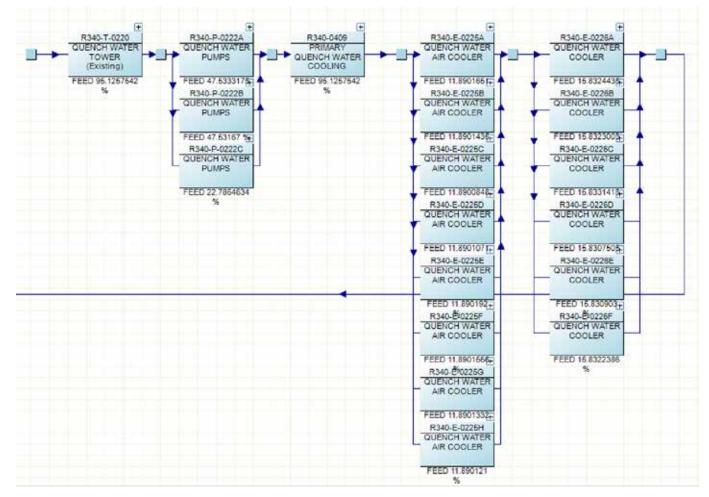
RBD Modelling & Techniques



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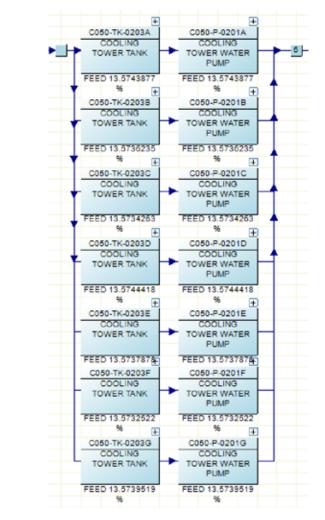


Redundancy Arrangements



BASED ON NODE PRODUCTION DEMAND

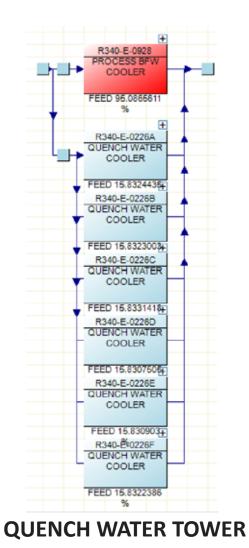
BASED ON NODE VOTE DEMAND

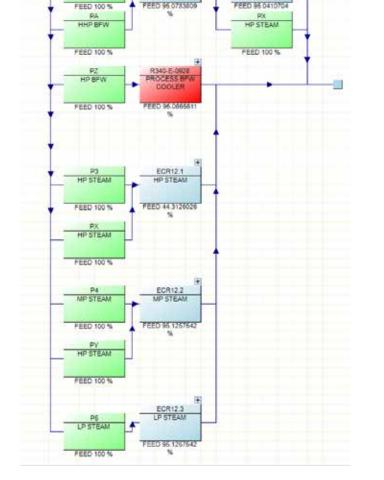




AINTEC Common Assets

Exchanger in a steam system and product system





R340-ST-0300 CGC TURBINE

HHP STEAM

R340-E-0302 CGC SURFACE

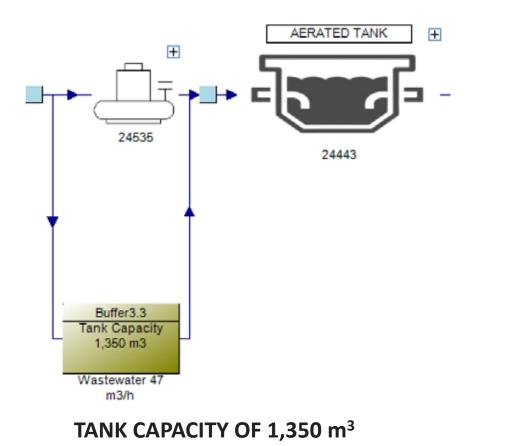
CONDENSER

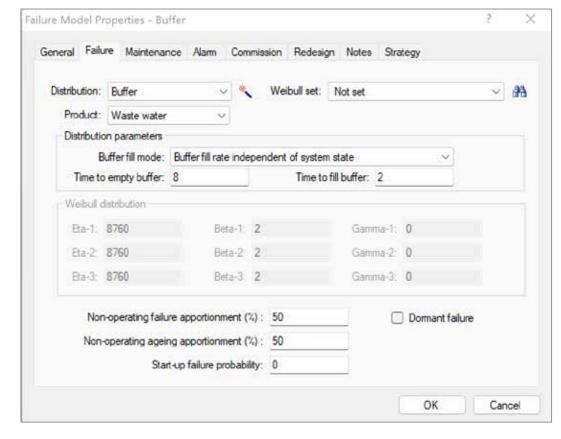
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STEAM DISTRIBUTION SYSTEM



Tank Storage and Buffer Capacity





TANK TAKES 8 HOURS TO EMPTY AND 2 TO FILL



AINTEC Opportunistic Maintenance

Properties - PM/	163 : Replace p	oump stator		2
aneral Advanced	Rules Note	es Optimization		
	Task enabl	ed		
Interval:	8760	Offset: 0	🗆 F	xed interval
Description:	Replace pump	stator		
Task ID:	PM463			
Task duration:	2	Operatio	nal cost: 0	
Ramp time:	0	Minin	ium age: 0	
Task group:	Not set			~ #
		New Group	Edit Group	P
lesources:				
MEC x 2 140298 x 1 ST 140298 x 1 ST 14020 x	ATOR, CAVITY	PUMP, 056009G54A1216		
🕈 Add 🍾	Add 👩	Add	Edt	Remove

ule Properties		7	×
Туре	Trigger task by state	~	
State dependency type:	RBD Block	~	
Reference block:	25645	~	#3
Reference block state:	Out of service	~	
Minimum elapsed time/age:	35000		
Rule description:			
If block 25645 is out of service trigger task i	f elapsed time/component age >= 350	00	

OUT OF SERVICE

PLANNED MAINTENANCE



Phases

hase Properties	Winter		?	>
General Notes				
ID:	Winter			
Group:	Not set		~	
Description:				
Duration:	2190			
		ОК	Cance	el

PHASES FOR SEASONS

Defau	1						
Derau	Jts		Wastewater	Water (m3/h)	Skudee	(m3/h)	Treated water
		Max capacity:	47	0	0	(IIIII)	0
		Logic mode:	Probabilistic	~			
		Standby mode:	11-1		Load factor:	1	
		standby mode.	HOL	~			
Rules	p		-	ks (non-repairable times to failure wit		(anable)	
Rules	20	Description	-			(anable)	
ID	20	· · · · · · · · · · · · · · · · · · ·	Use standby		nen o <mark>perating</mark>	(anable)	
ID Ru	6	Set Wastew	Use standby	times to failure wh	ase Winter	(anable)	
ID Ru Ru Ru	ule 1 ule 2 ule 3	Set Wastew Set Wastew Set Wastew	Use standby	times to failure wi 44 m3/h during ph 46 m3/h during ph 47 m3/h during ph	ase Winter ase Spring ase Summer	(anabie)	
ID Ru Ru Ru	ule 1 ule 2	Set Wastew Set Wastew Set Wastew	Use standby	times to failure wh 44 m3/h during ph 46 m3/h during ph	ase Winter ase Spring ase Summer	(anabie)	

CHANGING OF CAPACITY FOR WASTEWATER DURING SEASONS



MAINTEC Shutdowns, Turnarounds & Inspection

ID 👻	Asset Type	• E •	Event Type 🖛	Failure	Failure Mode	Υ.	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)

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SHUTDOWN MAINTENANCE AND INSPECTION TASKS



Shutdowns, Turnarounds & Inspection

Task Group Prop	erties – 10 Yearly	7 ×	Task G		perties - 10 Yearly	5		? ×	Task Group Propert	ies – 10 Yearl	Y		?
General Pred	ctive Data Rules Notes Tasks		Ge	neral Pred	active Data Rules	Notes Tasks			General Predictin	ve Data Rule	s Notes	Taska	
	10 Yearty				ea Assig	n rules to associated tasks			Failure Model CMP1.4 CMP2.4	Task PM5 PM9	Operation	Description Compressor major overhaul Compressor major overhaul	Enable
Type:	Not set	~	1	Rules					CMP3.5	PM14		Compressor major overhaul	
Description:				ID Rule 1	Description	g phase OPERATIONAL			TNK1.3	PM27		Internal inspection	8
	Assign description Enable associated tasks Assign interval to associated tasks Enable Assign interval			Add	Edt	Move Up List	Move Down List	Remove					
Interval	87600 Interval offset: 0 Bildency factor: 1 0 Operational cost: 0 0			Not	te that assigned rule	s will replace any existing r	ules for associated task	5.					
	ок	Cancel					ОК	Cancel				ОК	Cancel
		Carlos	6.7				UN						

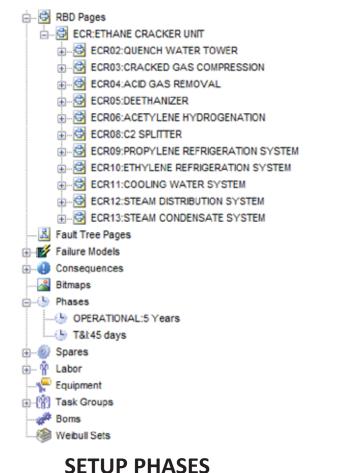
TASK GROUP

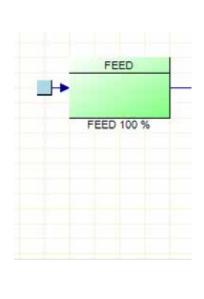
RULES TO ONLY PERFORM TASKS DURING T&I

TASKS IN GROUP



AINTEC Shutdowns, Turnarounds & Inspection





FEED BLOCK FOR

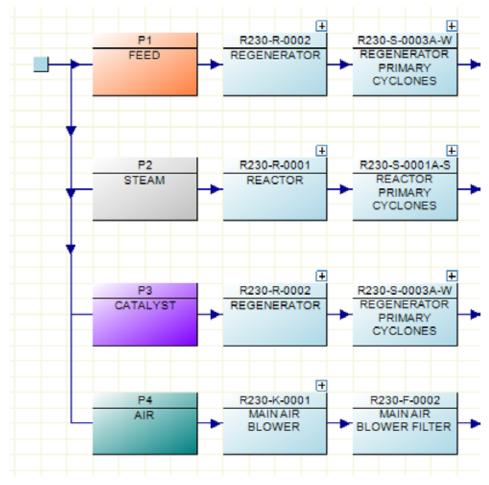
MODEL CONSTRAINTS

neral	Rule	s Ap	pearanc	e 1	Votes							
Defa	ults											
				FE	ED (%)							
		Max	capacity	: 10	0							
		Log	ic mode	Pr	obabilisti	0	\sim	load	factor	1		
		Stand	oy mode	Co	bld		~	2000	Tuetor	-	 -	
Dulas				-	000 0.0	naby and	es to failure	in ten op				
Rules	5 5	D				inder y en in		in left op		e		î
ID	•		escriptio							1		Î
ID Ru	5 5	Se	t logic n	node		bilistic du	iring phase					Î

SET RULES PER PHASE



NTEC Shutdowns, Turnarounds & Inspection



Defaults		FEED (kg/h)	STEAM (kg/h	CATAL	YST	AIR (kg/h)
	Max capacity:		0	0	131	0
	Logic mode:	Probabilistic	~		11	
	Standby mode:	Hot	~	Load factor:	1	_
Rules		Use standby	cs (non-repairable times to failure wh		tainable)	
Rules	Description	Use standby			tainable)	
ID Rule 1	Set FEED o	Use standby	times to failure wh	en operating se OPERATIK		
ID	Set FEED o	Use standby	times to failure wh	en operating se OPERATIK		

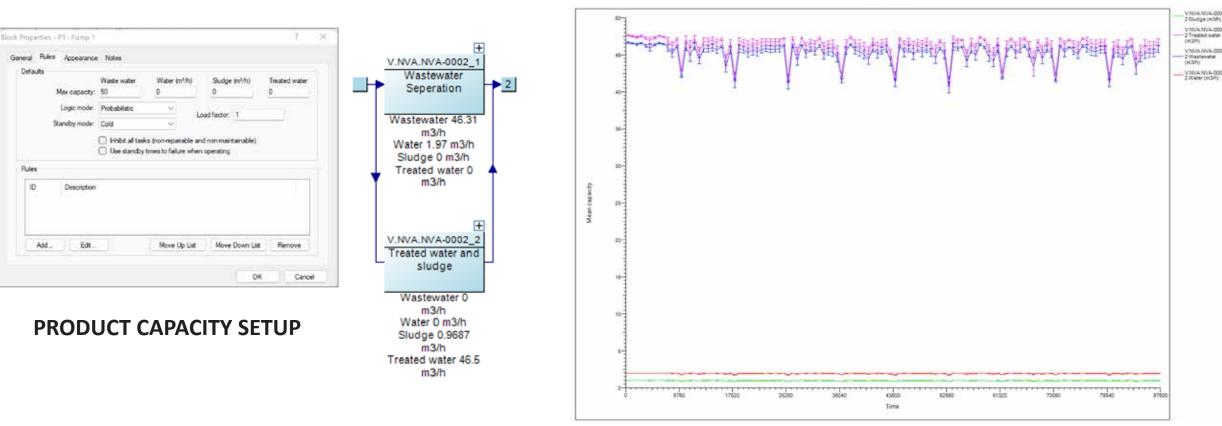
RULES TO SHUT OFF STREAMS DURING A SHUTDOWN

MULTIPLE FEED STREAMS

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Production Modelling



PARALLEL SYSTEMS

GRAPHICAL PRODUCTION OUTPUT OVER LIFECYCLE

System profile



Capacity Reduction

 Phases Wear Catalyst C1:Catalyst 100% C2:Catalyst 90% C3:Catalyst 75% 	General Notes ID: Group:	C2 Catalyst Catalyst 90%	? ×	Block Properties - R340-T-0220.4 ? General Rules Appearance Notes OUENCH Max capacity: 1871 Logic mode: Probabilistic Standby mode: Hot Inhibit all tasks (non-repairable and non-maintainable) Use standby times to failure when operating	×
Spares	Duration:	<u>8760</u> O	K Cancel	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	
	3		K Cancel	OK Cancel	

SETUP PHASES

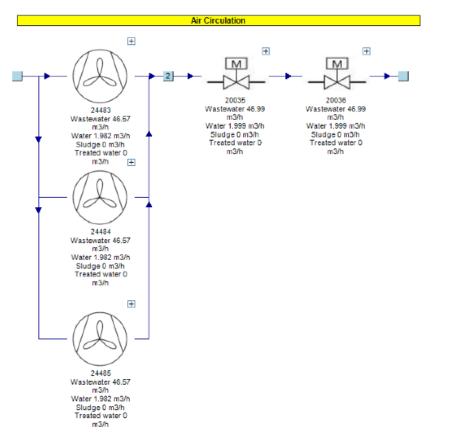
🚊 🕒 Phases

PHASES DEFINITION

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



Switching Delay



A.1 : Compressor seized		? ×
arance Notes		
MP1.A.1		
ompressor seized		
	Ŷ	<i>a</i> na
Vot set	~]	# 8
	÷	# 3
	01	Cancel
	arance Notes MP1A1 Compressor seized ELEC 1.A.1 New Edt Not set	arance Notes MP1.A.1 Compressor seized ELEC.1.A.1 New Edit Not set New Edit

2 AIR BLOWERS ON DUTY WITH 1 IN STANDBY

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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)

eneral Level	1 Level 2 Level 3 Repair Shop Notes	Optimization		
ID:	140298			
Type:	Not set		~	
Description:	STATOR, CAVITY PUMP. 056009G54A1216			
	Unit cost:	1250	_	
	Unit cost: Unit volume:	-	_	
		-		

SPARE SETUP

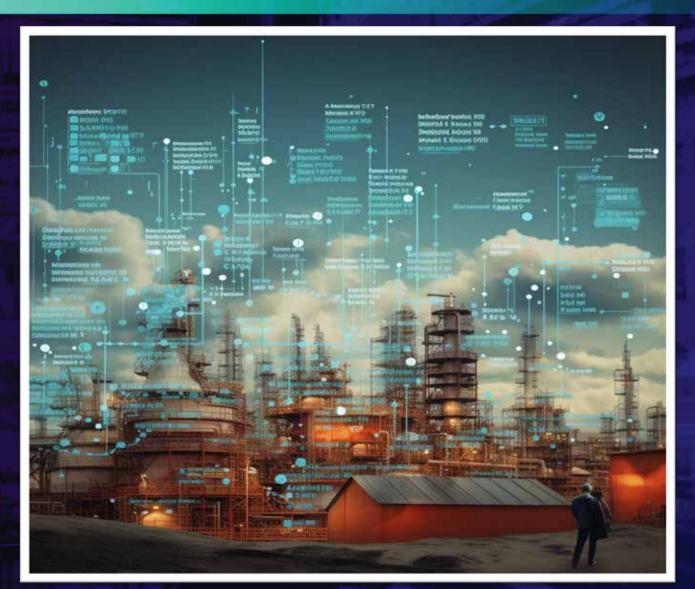
D	Level 1 Min	Level 1 Max	Level 1 Opt	Level 2 Min	Level 2 Max	Level 2 Opt	Sensitivity	
140298	0	6	0	0	6	1	0.02805	
Set range	for selected spare(s)	• ou	t of date					Select all

for the second s

SPARE INVENTORY OPTIMISATION



Industry and Site Data Integration



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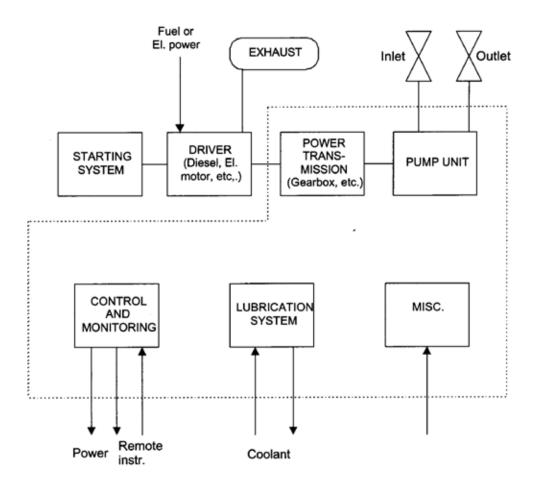
Industry Data Sources

- **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

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OREDA



		PUMP	고 20년 11년 전 지난 44	國主統建成任何
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 liner⁵ Piston Diaphragm⁶ Instruments 	 Instruments Cabling & junction boxes Control unit Actuating device Monitoring Internal power supply Valves 	 Reservoir w/heating system Pump w/motor Filter Cooler 	 Purge air Cooling/heating system Filter, cyclone Pulsation dampediation



Taxonomy no		Item									
1.3.1		Machiner	у								
		Pumps									
		Centrifuga	al								
Population	Installations		Aggrega	ted time ir	service (10	6 hours)			No of o	lemands	
350	59	Ca	lendar tim	e •	Opera	ational time	,†		10	340	
			13.9546	1		5.7455					
Failur	e mode	No of	No of Failure			hours).		Active	Rep	air (manh	
		failures	Lower	Mean	Upper	SD	nht	rep.hrs	Min	Mean	Max
Critical		464*	0.00	21.60	124.23	67.21	33.25	39.7	1.0	57.6	1025.
		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.
Lindad onder		2 [†]	0.00	0.46	2.22	0.92	0.35				
External leakad	e - Process	77*	0.00	2.25	5.52	11.84	5.52	30.2	2.0	42.0	444.
medium	,	77 [†]	0.00	7.04	38.07	17.67	13.40				
External leakad	e - Utility medium		0.00	1.61	2.94	9.28	3.30	16.0	2.0	29.8	90.
		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.
		42 [†]	0.02	13.74	55.88	21.10	7.31				
Fail to stop on a	demand	2.	0.00	0.13	0.65	0.57	0.14	3.5	3.0	3.5	4.
i da to stop on i	aomana	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.
riigh output		3 [†]	0.00	2.49	13.73	6.44	0.52				
Internal leakag	e	3*	0.00	0.16	0.87	0.57	0.21	188.0	36.0	90.7	188.
internet reeneg	-	31	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.
con output		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.
		4 [†]	0.03	0.78	2.34	0.80	0.70	1			
Other		8*	0.00	0.60	3.20	2.68	0.57	275.5	2.0	424.5	734.
0000		81	0.00	1.85		3.14	1.39				
Overheating		5.	0.11	0.36		0.19	0.36	183.2	3.0	265.0	1025.
o control ing		+	0.00	0.00	07.10	17.00	0.07				

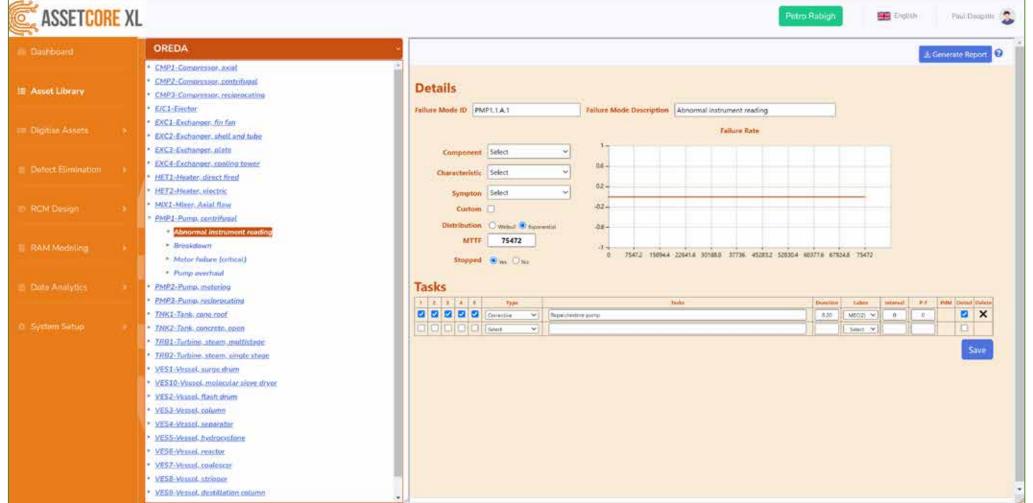
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OREDA DATA IN

ELECTRONIC FORMAT

Asset Library





Site Data



SYMPTOM or FM OREDA

Descriptions helps for data mining

90 # 2 05	ay PM Notification: Corrective Maint Req Image: Instruction in the second sec	Equipment at
otification	20440677 M2 120/repair G-301B lube oil leak,	tag level
lotific. Status	NOCO ORAS	
order	11255761	
Notification	FRACAS Data Area of Responsibility Location data Item History Enhancement	
Reference object		Equipment
Functional loc.	120-CR-DT0-G0301 G301 BOTTOM PUMPS COL-19	assigned to
Equipment	2825331 G301B STABLIZER 19 CENTREG BOTTOMS P	Ŭ
Assembly		classification
	uipment Number	
Start/End Dates		or asset type
Required Start	01/20/2017 07:41:17 Priority Med-Sch within 10day -	
Required End	03/21/2017 07:41:17 Breakdown Failure Mode	
Subject		
Failure Mode	PM041 L001 leakage- External/ fuel (ELF)	
Description	120/repair G-301B lube oil leak,	Malfunction
Subject Long Te	xt	
01/10/2017 08:4	3:07 UTC+3 M. Gharwi (GHARWIMH) Phone +966 13 572-3293	start is the
120/repair G-3018	B lube oil leak, ALSO TO IMPLEMENT ME&FA RECOMMENDATION	
		MTBF
		calculated
4 1	4 F	Calculated
5. Malfunctio	on Start /End Data 6. Breakdown Indicator	date
Malfunction data		uate
Malfunct. start	01/05/2017 00:00:00 Breakdown	
Malfunct.end	+01/06/2017 00:00:00 Breakdown dur. 24.00 H	

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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

Dis	play PM	Notification:	Corrective	Maint Req		
R 91 46 1	ð 🛢 🔂					
Notification	2044	0677 M2 120/r	epar G-301B lub	e ol leak,		
Notific. Status	NOC	O ORAS	3	HCON	3 22	
Order	1125	5761 6				
Notification	n 🦉 FR	ACAS Data Area	of Responsibility	Location data	Item History	Enhancement
Items	Causes	Item Activities	7. Object Par	t	8. Damage	
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Figure [1-B] - Fields Evaluated in SAP

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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
- € Condition (100 Conf

Combined Notification	on Repair Hist: S	election of Notific	ations	
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Figure [4] - ZI0110 SAP Screen



Site Data

Combined Notification Repair Hist: List of Notifications

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B S	Notification	Notf.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	2099	2099					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	PN01201	F001	F001					see attche	see attche
	11238290	09/12/2017	120/To address 3rd QSI finding			PM01213	PM01213	5017	\$017					see	566
	11238290	09/12/2017	120/To address 3rd QSI finding			PM01213	PM01213	5017	\$017	PM01213	PM01213	union fleak 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	cancelded	cancelded		
	11251314	10/29/2017	120/PIB-12 to verify VMS materials	work canceled.	work canceled.	PM011	PM011	K001	K001					canceided	cancelded
	11251315	10/29/2017	120/PIB-13 to verify VMS materials	cancelded	cancelded	PM011	PN011	K001	K001					cancelded	cancelded
	11251315	10/29/2017	120/PIB-13 to verify VMS materials	cancelded	cancelded	PM011	PM011	K001	K001	PM011	PM011	cancelded	cancelded		
	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	CALIERATION (adjust	CALIBRATION (adjust		
10	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	5033	\$033						
	20416695	05/30/2016	120/MOV1253 NOT WORKING-PMDR			PM01220	PM01220	5033	\$033	PM01220	PM01220				
	20417283	06/05/2016	120/EM302D1 NOT WORKING -PNDR			PM01202	PM01202	5027	5027						
	20417283	05/05/2016	120/EM302D1 NOT WORKING -PMDR			PM01202	PM01202	5027	\$027	PM01202	PM01202				
	20417285	06/05/2016	120/EM302H1 TERMINAL BOX BROKEN-	Broken Terminal box	Broken Terminal box	PM01202	PM01202	B026	8026	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	8026	8026					Broken Ter_	Broken Ter_
13	20417323	06/05/2016	120/Thrust bearing V 120-G-14			PM01201	PN01201	8004	8004					see attatch	see attatch
	20417323	05/05/2016	120/Thrust bearing V 120-G-14			PM01201	PM01201	8004	8004	PM01201	PM01201	WATER IN LUBE OIL	WATER IN LUBE OIL		
	20420315	07/11/2016	120/G-13/upnormal sound/ need repair	0		PM01203	PM01203	P027	P027	PM01203	PM01203	air inside the pump	air inside the pump		
1.00	20420316	07/11/2016	120/6-13/upnormal sound/ need repair			PM01203	PM01203	P027	P027					see attatch	see attatch

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Figure [5] – SAP ZI0110 Report



AINTEC Site Data

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DATA ANALYTICS

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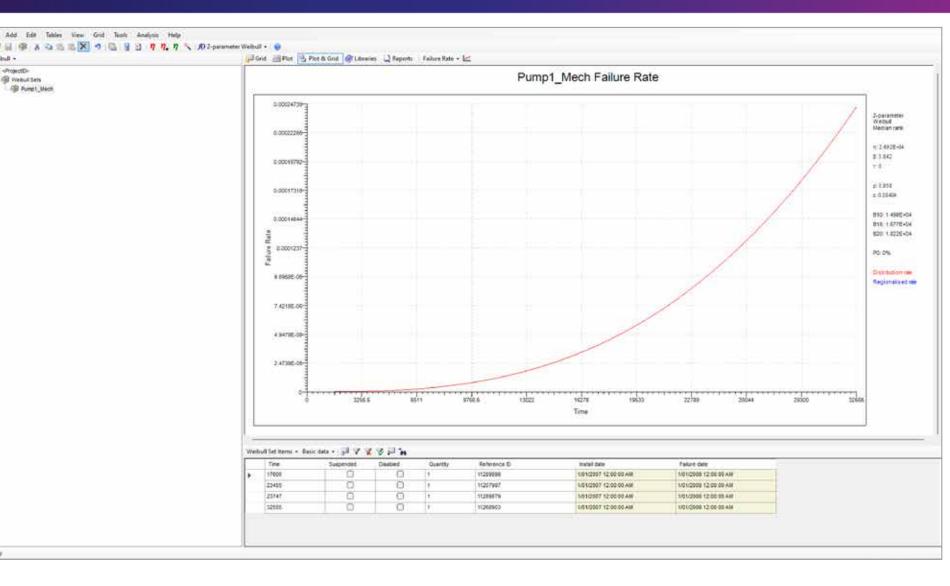
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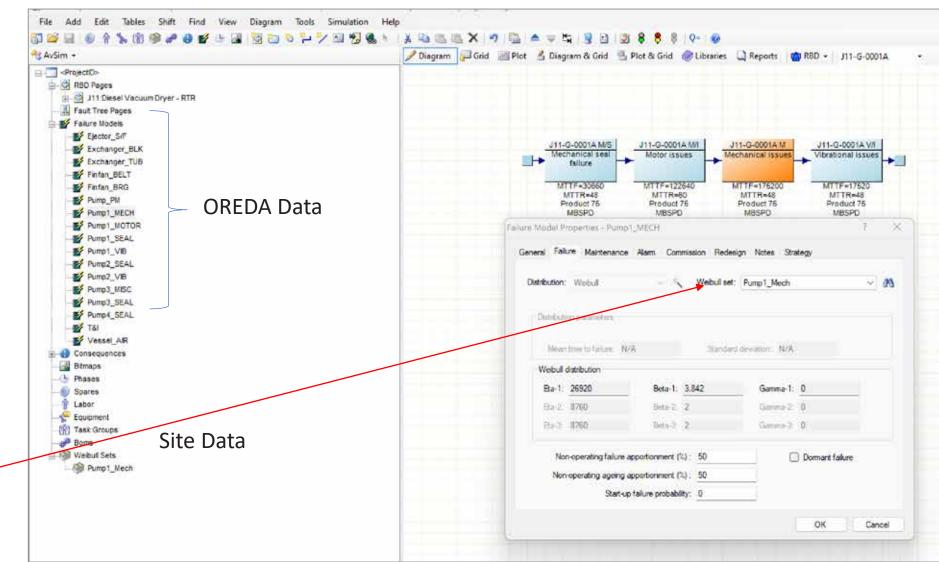




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AssetCoreXL Reporting

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ONLINE RAM RESULTS

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AssetCoreXL Reporting

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

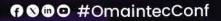
SAES-A-030 Appendix A

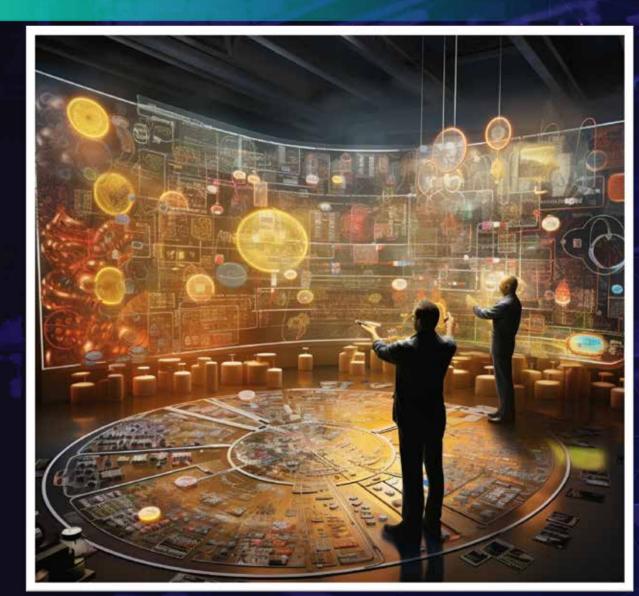
food #OmaintecConf

Page 1 of 43

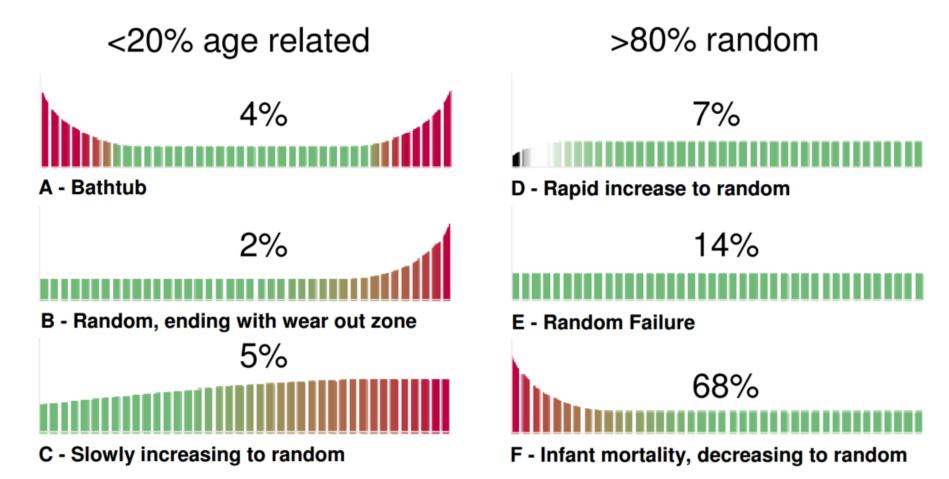


Evaluate RCM Decisions Against Production Targets



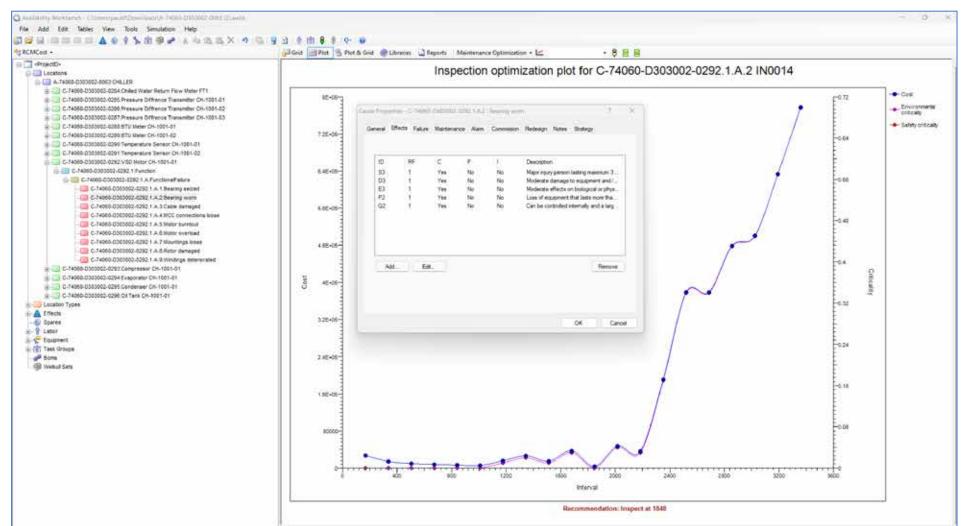








NTEC RCM Principles





Site Data

Failure mode:

CASING-BOTTOM TWISTED CAUSED BY DESIGN_INCORRECT

Displa	y PM NOU	ncation: c	Corrective Ma	int Req		
R 9 4 7 1	5 🕞					
Notification	20440677	M2 120/rep	air G-3018 lube of l	eak,		
Notific. Status	NOCO ORAS	1	I MCON	н		
		and the local division of the local division				
Order	11255761	55				
Order Notification	11255761		Responsibility L	ocation data 📈 I	tem History	Enhancement
Notification	and the second s	ta Area of	Responsibility L	location data 📈	8. Damage	Enhancement
Notification	FRACAS Da	ta Area of		.ocation data 🔏		
Notification	FRACAS Da	ta Area of ctwities 7.				

Figure [1-B] - Fields Evaluated in SAP

99936	3 #5							
Notification	20440677	M2 120	/repair G-3018 lube oil leak	ć				
Notific. Status	NOCO ORAS		I HCOM					
Order	11255761	60						
Notification	FRACAS Dat	Area	a of Responsibility Loc	ation data	Item History	Enhancen	nent	
For Rem 1	Ises Rem Ad		ACTIVE SOUTTON					
For item 1 Object part Damage	PH01201	C004 C	ASING- BOTTOM WISTED	- 69				ł
For item 1 Object part	PM01201	C004 C						
For item 1 Object part Damage	PH01201 PH01201	C004 C	WISTED					
For item 1 Object part Damage Text Causes for Item	PH01201 PH01201	C004 C	WISTED		Created By	Created On	Cre	Changed by

Figure [1-C] – Fields Evaluated in SAP

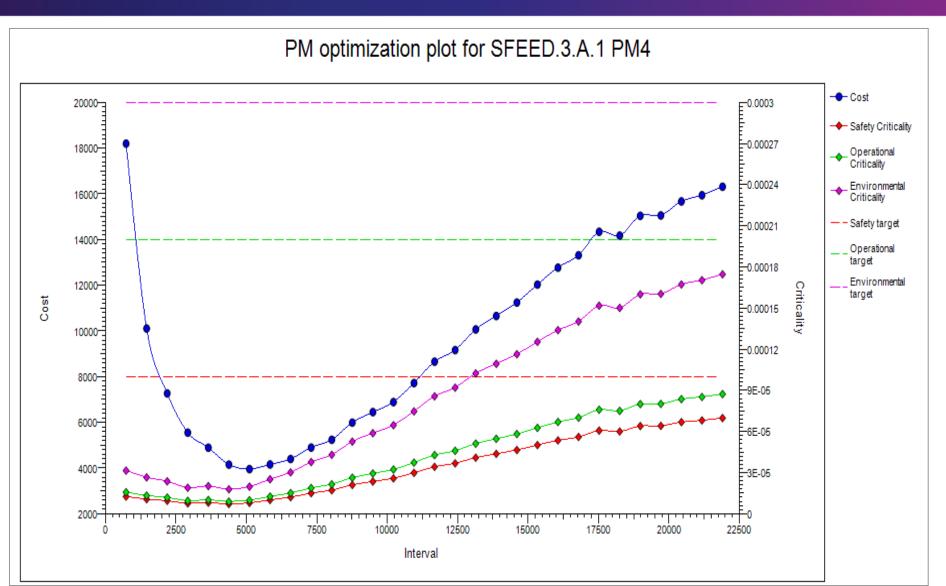
🕈 🫅 Object part	Object parts	-
- m FM01201	Pumps- General	
· • 3002	BEARING- RADIAL ANTI-FRICTION	
 B003 	BEARING- RADIAL SLEEVE	
 B004 	BEARING- THRUST ANTSFRICTION	
· > B014	BOLT- GENERAL	
 > \$ \$022 	BUSH- THROTTLE	
 > C003 	CASING-SEAL	
+ > C004	CASING- BOTTOM	
· • C011	COLLAR - DRIVE C	
 > C018 	COUPLING- DEAPHRAGM TYPE	
· • C058	COUPLING- GEAR TYPE	
 b C020 	COUPLING- GENERAL	
 CO21 	COVER- END	
 > C022 	COVER- VENT	
 > C023 	COVER- CASING/TOP 3	
 D001 	DETECTOR- VIBRATION (XVE)	
+ > D004	DISK- THRUST BEARING	
 > poos 	DIVIDER- FLOW	
 > 0007 	DRAIN	
· • E001	ELBOW- GENERAL	
 > ± ±006 	ELEMENT- ROTATING EQUIPMENT UNIT	
· . F001	FACE-SEAL ROTATING	
· • # #002	FACE- SEAL STATIONARY	
· > \$007	FLANGE- BLIND	
2 h 2112	the asset of property as	

* 🛅 Damage	Overview of damage	_
* E 2801201	Pumps- General	
 > 8001 	BENT/KINKED	
· > \$005	BROKEN CA	
 > 2004 	BURNT (C)	
 B005 	BURST 🚯	
 > 3004 	BLISTER (ed), (mp)	
- > C001	CHIPPED	
 C002 	COLLAPSED	
< > C003	CRACKED/FRACTURED	
 C004 	CORRODED 1	
- > C005	ORUSHED	
 C006 	CUT	
 > D001 	DENT/DENTED	
- > E001	ERODED 12	
· • 0001	GALLED	
- > H001	HOLED	
· > H001	MELTED	
 > 8002 	METAL LOSS	
- > P001	PIERCED	
< > P002	PITTED	
- > 2003	PUNCTURED	
 # #001 	RUPTURED	
· • \$ 5001	SCALED/SCALING	
 \$ \$5002 	SORATCHED/SCORED	
	rene	

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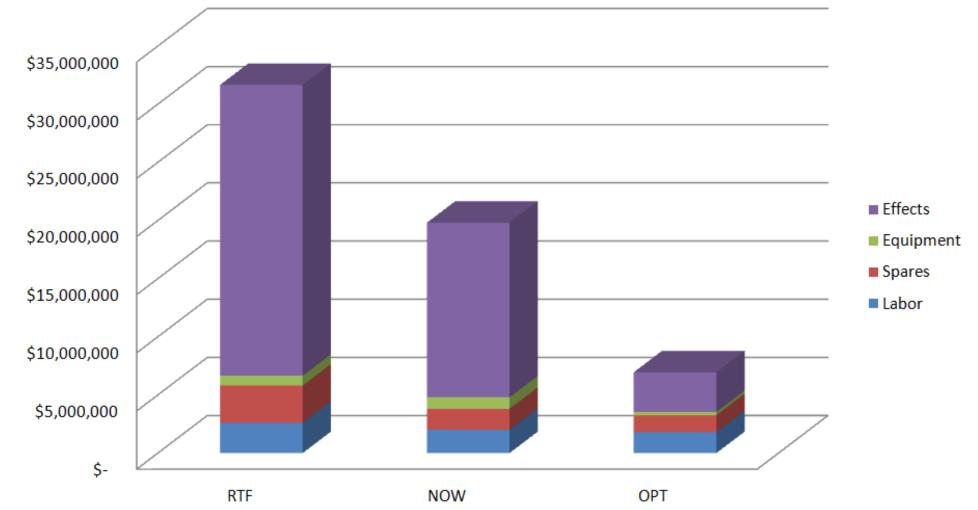


Optimisation



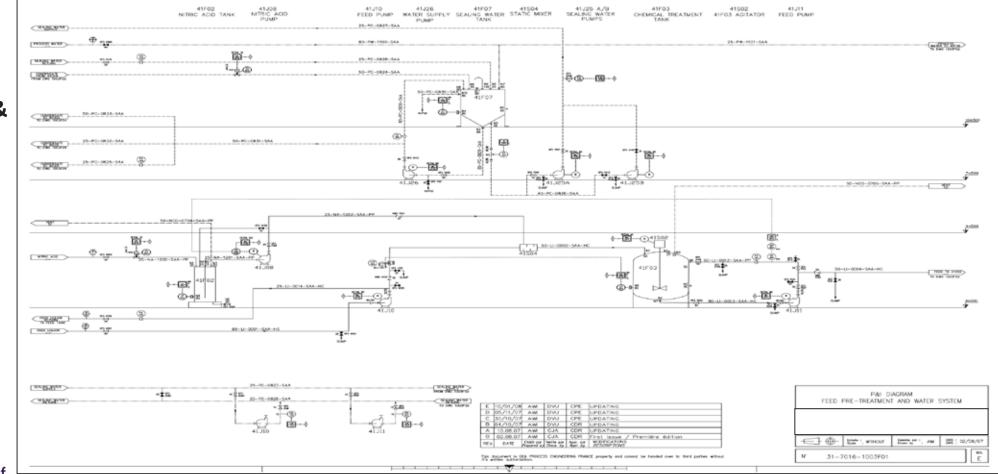
GOD #OmaintecConf





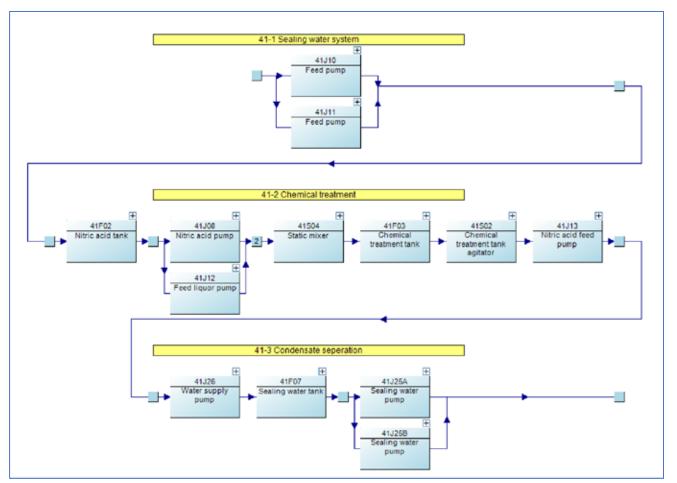


FEED PRE-TREATMENT & WATER SYSTEM



6000 #OmaintecConf





GOD #OmaintecConf

			par nov	nings						
			sabled]: F	Repair mount	nge					
14	N031		ect foots	iga, mountin	gs for wea	. contosio	s & dama	ge.		
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Task	bay.									

0	Description		
41	Feed on teatry	ert and water aystem	- 33
41-1	Sealing water to		
41,10	Feed pump		
41J10/FSL112	Row Switch Low		
41210 MC001	Matrix contest or	rite	
	10	41	
	Tittal down time:	6902	
	Shi total down time:	1114	
Er.	or "Litital down time:	5.102	
Tinated +	ister Wear capacity:	92.12 m3/fr	
Tiesto	water 3td capacity	1271e3fr	
Tieated wa	welling 'L capacity'	0.4364	
	Mean unavailability:	0.07679	
UN	rvalability at lifetime	0	
	No of outages	403.3	
	Std no of outages.	7,747	
6	ins "Line of outages.	0.6074	
		1	
	Time in dandby:	0	
	'MTTD	490.5	
	'MTBD	217.2	
	'MTTR.	17.11	
		* To obtain accurate MITTO, MTBO and NITTR values set project lifetime 33 MTB	0



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)
1F02-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 handralls & 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 handralls & ladders for excessive corrosion, looseness or damage.	8760	0.2	MEC(1)
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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 handralls & 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)
41503-AG001	Visual inspection of impeller for wear, looseness & damage.	8760	1	MEC(1)
41503-AG001	Inspect shaft for eccentricity.	8760	0.5	MEC(1)
41503-AG001	Inspect footings, mountings for wear, corrosion & damage.	8760	0.1	MEC(1)
41504-MX001	Visual inspection of impeller for wear, looseness & damage.	8760	1	MEC(1)
41504-MX001	Inspect shaft for eccentricity.	8760	0.5	MEC(1)
41504-MX001	Inspect footings, mountings for wear, corrosion & damage.	8760	0.1	MEC(1)

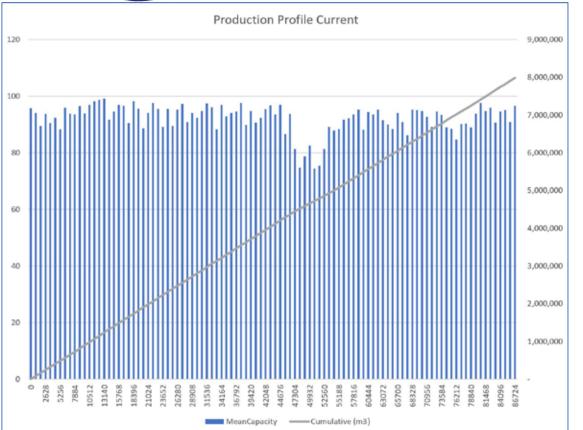
ME1Y ANNUAL MECHANICAL PREVENTIVE MAINTENANCE (CURRENT)

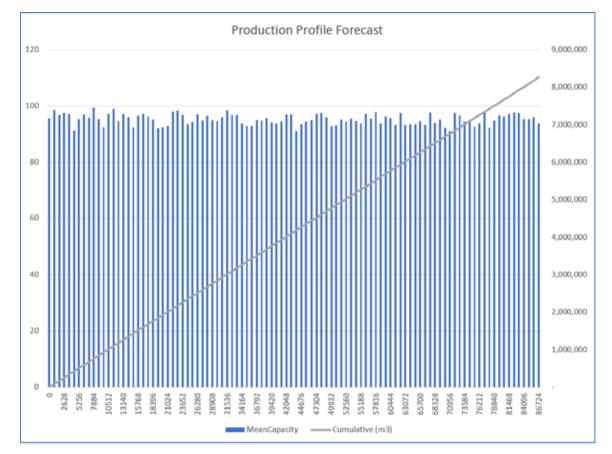
Asset Interval Duration Trade 41F02-TK001 Check the integrity of any earth or ground system cabling 8760 0.1 MEC(1) 17520 41F02-TK001 Check condition of any manholes and clean out doors. 0.2 MEC(1) 41F02-TK001 Visual inspection of the tank and shell of any distortion 8760 0.2 MEC(1) 41F02-TK001 Inspect 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 0.2 MEC(1) 8760 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) 17520 0.1 MEC(1) 41J08-PP001 Inspect footings, mountings for wear, corrosion & damage. 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) 17520 41J11-PP001 Inspect footings, mountings for wear, corrosion & damage. 0.1 MEC(1) 41J12-PP001 Inspect footings, mountings for wear, corrosion & damage. 17520 0.1 MEC(1) 17520 41J13-PP001 Inspect footings, mountings for wear, corrosion & damage. 0.1 MEC(1) 41/26-PP001 Inspect footings, mountings for wear, corrosion & damage. 17520 0.1 MEC(1) 41503-AG001 Visual inspection of impeller for wear, looseness & damage. 43800 1 MEC(1) 41503-AG001 Inspect shaft for eccentricity. 17520 0.5 MEC(1) 41503-AG001 Inspect footings, mountings for wear, corrosion & damage. 17520 0.1 MEC(1) 41504-MX001 Visual inspection of impeller for wear, looseness & damage. 43800 1 MEC(1) 41S04-MX001 Inspect shaft for eccentricity. 17520 0.5 MEC(1) 41504-MX001 Inspect footings, mountings for wear, corrosion & damage. 17520 0.1 MEC(1)

AFTER OPTIMISATION

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8,265,061 m³ TOTAL m³ (FORECAST)

3.51% 279,958 m³ ADDITIONAL PRODUCT

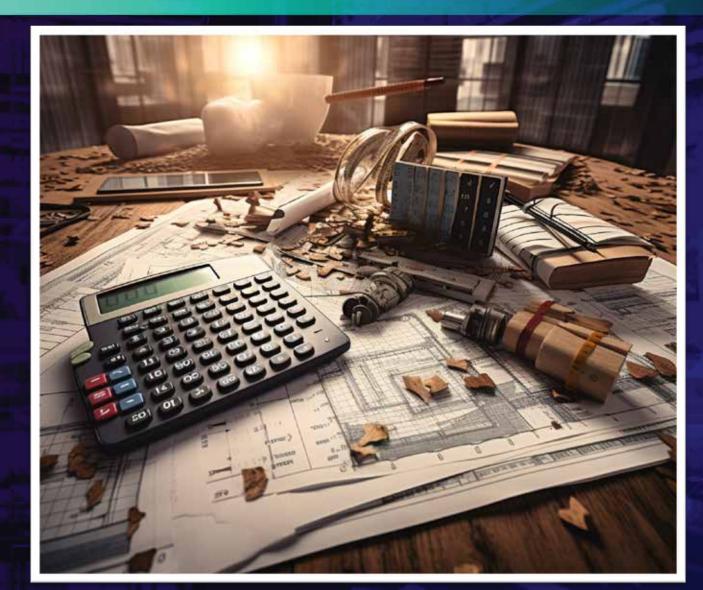
7,985,103 m³ TOTAL m³ (CURRENT)

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



Maintenance Budgeting & NPV Calculations Over Asset Life



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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



MAINTEC Maintenance Budget

	LIFELL LL L			? X		Spare Properties	- M6 : Compressor motor	? ×
Labor Properties General Notes		nical Fitter		I A		General Level	1 Level 2 Level 3 Repair Shop Notes	Optimization
ID:	MECH					ID:	M6	
Type:	Not set			~		Туре:	Not set	\sim
Description:	Mechanical Fitter	t.	-				Compressor motor	
				Equipment Prop	perties - Equipment1	? >	<	
4	Number available:	1000	Cost rate: 25	General Note	es		Unit cost	65000
Сопес	tive <mark>logistic delay:</mark>	1					Unit volume	
Correc	ctive call-out cost:	50		ID:	: C1		Unit weight	
Sched	luled call-out cost:	0		Type:	Not set	~	Una Hoight	Lookg
			ОК	Description:	: Small crane			OK Cancel
1	LA	BOR SETUP		Com	Number available: 12 active logistic delay: 1 active call-out cost: 200 aduled call-out cost: 0	Cost rate: 150	SPARE SET	UP
600	🗩 #Omain	tecConf				OK Cancel		

EQUIPMENT SETUP



AINTEC Maintenance Budget

	- Planned - PMT - Inspection	7: Replac 7: Overha	e bearings iul pump J]: Perform vit	aration mon	itoring survey					
			Edit					F	Remove	
	New		Second							
	New Copy Tas			🗍 Use cu	ment project	🗌 Use t	ask group	hierarchy		
217				Use cu	rrent project	🗌 Use t	ask grout	hierarchy		
217	Copy Tas			Use cu	ment project	🗌 Use t	ask grout	o hierarchy	~]
2017	Copy Tas			Use cu	rrent project	🗌 Use t	ask grout	b hierarchy		

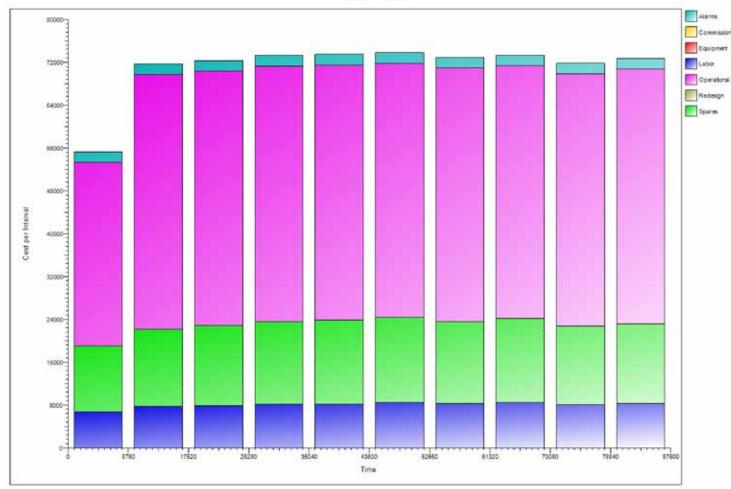
Seneral Advanced	7 : Replace bearings				
Advanced	Notes				
Description:	Replace bearings				
Task ID:	CM7				
Task duration:	4	Operational cost:	500		
D	0.5				
Ramp time:					
Resources: [®] F2 x 1 Fitter - C C1 x 1 Small ci [®] BB-3XY8395A	General				
Resources: F2 x 1 Fitter - (C1 x 1 Small ci BB-3XY8395A DSA-1709645	General rane .x 14 Ball bearings	Edit		Remove	

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Maintenance Budget

Cost Profile



Simulation Results X 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

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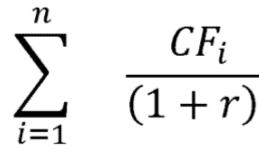


AINTEC Net Present Value

•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.).



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

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r = rate of return





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



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.



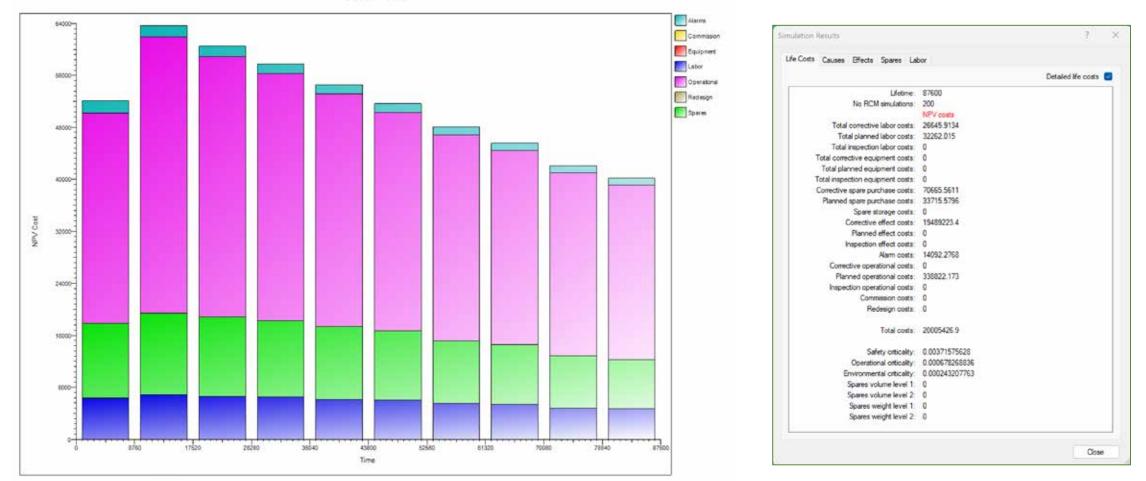
General	Lifetime	Simulation	Products	NPV	Spares	Impo	tance	Capacity Ava	ailability	•
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SETUP NPV VALUES FOR SIMULTION



Cost Profile





AINTEC 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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