

OPTIMIZING PUMP OPERATION & LIFESPAN USING SATEC ANALYZERS





Background

Rotating loads account for about 60-70% of power consumption worldwide. SATEC solutions help to optimize pump operations through advanced measurement and insightful data analysis.

The Role & Types of Pumping Systems:

There are three primary pump types to be considered:

- 1. Positive-Displacement
- 2. Centrifugal
- 3. Axial-Flow (including multiple subcategories)

In large industrial facilities (such as water utilities, factories, etc.) a great deal of information can be obtained by performing relatively simple measurements. These could indicate problems which should be addressed before major failures occur, often resulting in considerable expenses.

Monitoring 3-Phase Induction Motors

Most pumps are powered by 3-phase induction motors, each characterized by distinct operational parameters which warrant close monitoring. The motor plate, a valuable resource, provides the nominal electrical parameters (designed and tested) for motor operation, as set by the manufacturer.

Weg v	122	Prei	nium	IE3 - 9	96.9%	ME95 L	(D) 38324	CE	.91	DE 0530 EC 6003) 4
~ 3 FRAME	3151 -	-04	IP55		±80κ			MOD.TE1	BF0X0200003	01635	
$V = \Lambda/\Upsilon$	Hz	kW	0		COSØ	W2	о ^{U2}	V2	<u>_W2</u>	U2	V2
380/660	50	250	1490	451/260	0.87	UI UI	¢V1	JW1	الل _ې	_♀ V1	o ^{₩1}
400/690	50	250	1490	433/251	0.86	∆ L1	L2	L3	Y L1	L2	L3
415/ -	50	250	1490	422/ -	0.85						
440/ -	60	290	1785	447/ -	0.88	lan → 631	9-C3((45g)	MOBIL	POLY	REX EM
460/ -	60	290	1790	432/ -	0.87	⊟ → 631	6-C3((34g)	11000) h	
DUTY S1		AMB.	40°C	SF 1.15	Alt 1 ()00 m.a	a.s.l.	WEIGH	154	-6 kg	

Image 1: motor plate sample

This includes information such as the required wiring configuration (delta or wye connection) and voltage requirements. Understanding these parameters helps to set appropriate thresholds for effective monitoring.

Critical Parameters for Monitoring

Overload

The current example, calculated by frequency and voltage, the motor's rated (nominal) power is 250KW. In this case, a threshold can be set in PAS to generate an alert in case the motor exceeds its rated power, since it can cause overheating and subsequent catastrophic failure due to insulation degradation and breakdown. Note: In order to avoid excessive/unwarranted alerts, it is recommended to program a setpoint at 10% above rated power, with a 60-second operate delay.

PM335	5 - Ge	neral Sei	tup						×
Displa	ay Setu c. Setu	up Re	lay Outputs Co levice Options	ounters Con	Transformer Cor htrol/Alarm Setpoints	rection	VIM CIM Se alog Outputs	tup Periodic Tim	ners Local Settings
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Image 2: configuring an overload setpoint in the PRO PM335

Overcurrent

Overcurrent analysis is significantly enhanced by placing dedicated analyzers, such as those offered by SATEC, the PRO Series and the PM180, which calculate ½ and 1 cycle values for both starting current and inrush current. Inrush current, which frequently exceeds nominal current by a factor of six and exhibits a transient nature, may trigger insulation deterioration. A surge of inrush current, along with heightened mechanical torque, could potentially set off critical failures of motors and pumps. This has substantial adverse impact on the lifespan of equipment.

i335 - Jisplay	Gen Setup	eral Set	up ayOutputs Co	unters	Transf	omer Co	rection	VIM CIM	Setup Periodic	Timers Local Setting
Basic S	Setup	D	evice Options	Cor	ntrol/Alarm	Setpoint	s Ar	nalog Outpu	ts Analog Ing	outs Digital Inputs
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		,			9	etnoint	Triggers			
OR/A	ND		Input Group		Triac	er Param	eter	Relation	Operate limit	Release limit
OR	-	HIGH PI	HASE (1 cycle)	-	AHIGH		•	>= •	496	451
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OR	-			-						
OR	-			-						
OR	•			-						
OR	-			-						
OR	-			-						
OR	-			-						
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No			Action	Actio	ns Taro	et	Para	meter	Operate delay	elays, s
1	EVE	NT LOG	Action	-	OPER			motor	Release delay	10
2				.						
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Image 3: configuring an overcurrent setpoint in the PRO PM335

Monitoring Overcurrent in Inrush Current

Utilizing the PRO Series or the PM180 analyzers, the user can capture motor startup current waveforms. The Operating limit can be strategically set slightly above anticipated inrush currents, in order to avoid false triggers from normal starting currents. The release limit aligns with the motor's rated current. For example, if $I_n = 451A$, the estimated inrush current is $I_{Inrush} \sim 2750A$ (six times the nominal current).

Additionally, an embedded relay offers options by generating alarms or safeguarding equipment when connecting to the circuit breaker's shunt trip mechanism.

PM335 -	Gen	eral Setup						;
Display Basic	Setup Setup	p Relay Outputs Cou Device Options	unters Con	Transformer Co trol/Alarm Setpoint	rrection s Ar	VIM CIM Se nalog Outputs	tup Periodic Tim Analog Input	ners Local Settings s Digital Inputs
Set	tpoint	t No. 1						
				Setpoint	Triggers	•		
OR/A	AND	Input Group		Trigger Param	neter	Relation	Operate limit	Release limit
OR	•	RMS (1/2 cycle)	•	11	•	>= 💌	2750	451
OR	•	RMS (1/2 cycle)	•	12	-	>= 💌	2750	451
OR	•	RMS (1/2 cycle)	•	13	•	>= 💌	2750	451
OR	•		•					
OR	•		•					
OR	•		•					
OR	•		•					
OR	•		•					
No		Action	Actio	Taraat	Dara	mator	Dela	ays, s
1	EVE	ACIUM			Para	meter	Operate delay	0
2	WA	VEFORM LOG		#1 •				3
3	OPE	RATE RELAY		±1 💌				
4								
	Ор	en Save as	C	Clear Clea	r All	Print	Send	Receive
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Image 4: configuring an inrush current setpoint in the PRO PM335

Current & Voltage Unbalance

Three-phase motors are naturally balanced loads, ideally distributing the load equally across each phase during normal operation. However, real-world scenarios often introduce minor imbalances. Systematic tracking of the current unbalance rate flags potential problems. This metric not only highlights efficiency concerns, but also unveils more serious problems such as motor and pump vibrations.

PM335 - Display Basic	- Gen Setu Setup	eral Setup p Relay Outputs Co p Device Options	unters Con	Transformer Cor trol/Alarm Setpoints	rection s An	VIM CIM Se alog Outputs	tup Periodic Tim Analog Input	> ners Local Settings s Digital Inputs
Se	tpoint	No. 1		Setnoint -	Triagers			
OR		Input Group		Trigger Param	eter	Relation	Operate limit	Release limit
OR		AUX (1 cycle)	-	LUNB%		>= 💌	15	5
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	_		Actio	ns			Dela	ays, s
No.	F 1/7	Action		Target	Para	meter	Operate delay	60
1	EVE	INT LOG					Release delay	10
- 2	DAI	ALUG	<u> </u>	•1				
4								
	Ор	en Save as	C	Clear Clear	AI	Print	Send	Receive
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Image 5: configuring a current unbalance setpoint in the PRO PM335

Unusually high current unbalance, particularly in the absence of corresponding voltage unbalance, could signify a phase or winding fault. To augment analysis diverse setpoints can be configured for voltage unbalance as well, expanding fault detection capabilities.

Basic S	Setup	b Device Options	s Cor	trol/Alarm Setpoi	nts Ar	alog Outputs	Analog Input:	s Digital Inputs
				Setpoin	t Triggers			
OR/A	ND	Input Group)	Trigger Para	meter	Relation	Operate limit	Release limit
AND	•	AUX (1 cycle)	-	V UNB%	•	>= 💌	4	2
OR	•		-					
OR	•		-					
OR	•		-					
OR	•		-					
OR	•		-					
OR	•		-					
OR	•		-					
	_		Actio	ns			Dela	ivs. s
No.		Action		Target	Para	meter	Operate delay	600
1	EVE	ENT LOG	- (OPER	·		Release delay	10
2	DAT	TA LOG	- #	±1			·	
3			-					
4			-					
	Op	ben Save as	. 0	Clear Cle	ar All	Print	Send	Receive

Image 6: configuring a voltage unbalance setpoint in the PRO PM335

Undervoltage

Pumps and electric motors exhibit sensitivity to undervoltage conditions. When voltage decreases below a certain threshold, torque experiences a quadratic reduction.

One solution could be to configure a setpoint 10% below nominal voltage, not coupled with any time delay. This approach is recommended due to the immediate and direct impact of undervoltage conditions on equipment performance.

M335 -	Gen	eral Setup					×
Display Basic S	Setup Setup	Relay Outputs Counter Device Options Counter	rs Transformer Co ontrol/Alarm Setpoint	rrection s An	VIM CIM Se alog Outputs	tup Periodic Tim Analog Input	s Digital Inputs
Set	tpoint	No. 1					
			Setpoint	Triggers			
OR/A	AND	Input Group	Trigger Param	neter	Relation	Operate limit	Release limit
AND	•	LOW PHASE (1 cycle)	V LOW	•	<=	360	395
OR	•						
OR	•						
OR	•		•				
OR	•		•				
OR	•						
OR	•						
OR	•		·				
	_	A - 41				0.1	
No	1	Action	Target	Dara	motor	Dela	ays, s
1	FVF	INTLOG		Fala	meter	Delease delay	1
2		······································				Release deidy	10
3							
4							
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Image 7: configuring an undervoltage setpoint in the PRO PM335

THD & TDD - Harmonic Indicators

THD (Total Harmonic Distortion) and TDD (Total Demand Distortion) are significant because they offer harmonic detection within induction motors. These parameters are measured as a percentage relative to the 50Hz/60Hz 1st harmonic.

While characteristic thresholds which are specific to motor-related issues are currently unavailable, established standards such as IEEE 519 or EN50160 can be employed. These values are typically measured at facility settings, presenting an opportunity to install a power quality (PQ) analyzer if it is not already implemented. Collaboration with the facility's electrical engineer(s) is advised to facilitate setup.

The impact of harmonics extends beyond motor overheating, potentially impacting the entire system. Elevated frequencies lead to heightened turn-to-turn voltage, while working torque experiences reduction, necessitating vigilant analysis and management.

PM33	5 - (Gen	eral Setup					×
Displ Basi	ay S ic Se	ietuș etup	Device Options Counter	s Transformer Co ntrol/Alarm Setpoint	rrection s Ar	VIM CIM Se aalog Outputs	tup Periodic Tim Analog Inputs	ers Local Settings s Digital Inputs
	Setp	oint	No. 1					
		10	have a comp	Setpoint	Triggers	Deletier	On a set a line it	Deleges field
				I rigger Param	leter	Relation	o Operate limit	
	2		HIGH PHASE (1 cycle)			~ •	5	2
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Image 8: configuring a THD/TDD setpoint in the PRO PM335

Flow & Efficiency Analysis

Using the PRO Series analyzers, equipped with an on-board analog input, we connect to a 0/4-20mA flow meter. This configuration enables the device to trigger alerts when efficiency deviations are detected, facilitating swift corrective action.

		Setpoint Tri	iggers	•		
ID Input Group		Trigger Paramete	er	Relation	Operate limit	Release limit
TOTAL (1 sec)	•	kW	-	>= 💌	17.000	17.000
 Al (1 sec) 	-	All	-	<= 💌	300	300
▼	•					
▼	•					
▼	•					
▼	•					
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▼	•					
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Action	ction	Target	Dara	meter	Dela	iys, s
EVENTLOG	- L A		Fala	meter	Delegas delay	5.000
DATA LOG	- #	1				3.000
	- 1					
		I				
	TOTAL (1 sec) Al (1 sec) Al (1 sec) Artion CVENT LOG DATA LOG	TOTAL (1 sec) Al (1 sec)	TOTAL (1 sec) KW Al (1 sec) Al1 Al1	TOTAL (1 sec) KW Al (1 sec) Al1 Al1	▼ TOTAL (1 sec) ▼ KW > = ▼ ▲ Al (1 sec) ▲ Al1 ▼ <=	▼ TOTAL (1 sec) ▼ KW >= ▼ 17.000 ▲ Al (1 sec) ▲ Al1 ▼ <=

Image 9: configuring setpoints for flow efficiency monitoring in the PRO PM335



Reviewing the pump's performance curve reveals the correlation of flow with rated power. This curve is also useful for monitoring motor temperature through a PT1000/100 sensor.

Image 10: pump performance curve

Enhancing Value with Expertpower

Expertpower (SaaS) offers an additional layer of value by sending notifications to users (via email) when significant events occur. This feature substantially aids in Predictive Maintenance, leading to cost reduction and extending the lifespan of the system.

Users can conveniently access a comprehensive record of events through the Event Log page. Below is a brief workflow which details the setup of a setpoint (SP) in Expertpower.

Setpoint Event	Setpoint activity	Comm. activity	Front pan	el activity
Self-check	Self-update	Run-lime Error	Hardware	Event
External Event	Corrupted			Submil
Drag a column header No	Date / Time	Description	Details	Value

Image 11: configuring an Expertpower event log

Creating Analyzed Events for Notification

The presented solution involves generating an **Analyzed Event** for each flagged occurrence. Following this, specific conditions are set, as depicted below:

				Cie	ar Back Save
Event Name				Select Event Source	
Unbalance				Event Log	Ŷ
Start Message					
Unbalnce High				I SATEC	
End Message					
Onbaince Norma					
Open Action	C	lose Action			
None	•	None	~		
Description in map (Up	to 15 characte	ns)			
Description in ma	ар				
Warning Level					
Info	Warnin	a C	ritical		
Description					Conditions

Image 12: configuring Expertpower Analyzed Events

Configuring Device Events

Customer: SATE	C Event Name:				
Define Event C	iteria			Define Time Criteria	Back Sav
Starting Threshold	SETPOINT #4	Operated V	Ending Threshold	SETPOINT #4	Released V

Image 13: configuring an analyzed events

Following this, event settings are configured for the various devices.

Select Category			Exist	ing E	Remove Al	
Analyzed	~		W	8	I/O board EEPROM fault	×
			ω	⚠	Low Battery	×
Select Event Types				8	POWER DOWN	×
_			Ø	⊗	POWER UP	×
System	<u>^</u>		Ø	⊗	RAM/Data ERROR	×
consumption event test				⊗	ROM ERROR/Permanent fault	23
Demo Event			۵	8	SAMPLING FAIL	53
 High Power out of working hours sdf SP1 - High Unbalance Unbalance בדיקה 			(II)	8	TIMING FAIL/Software exception trap	×
			(U)	8	Transient Coprocessor Fault	×
			ω	⊗	WDT RESET	×
		-	B Eve	Event Log \ External Event		×
מקדם הספק יומי נמוך 🔲 —			Ø	φ	POWER DOWN	×
מתח אפס באחת הפאזות 🗌			Ø	Ģ	POWER UP	×
צריכה חריגה — צריכת יתר בשנאי קירור — — Generator Controller		-	🗆 Po	Power Quality \ PQ IEEE1159		×
			ω			23
— Air flap electrical trip				⊗	Undervoltages	X
Air flap shutdown Air flap warning		1	e Po	Power Quality \ EN50160-2007 Standard		23
	+		ω	Φ	Mains Signaling Voltage	×
Choose Warning Level			(II)	⊗	Voltage Dips	23
	,			۲	Voltage Unbalance	×
Display in map and summary		(B Sys	stem	alerts \ Expert power Agent service	23
_				Φ	Backup process Failed	22
	Add		m	G	Global orror	

Image 14: configuring event settings

stomer: SA	EC		
Event Type		Open Action	Close Action
Analyzed \ U	ser		
⊗ (Inbalance	e-mail 🗸	e-mail 🗸
Application \	Communication		
🛞 I	Io connection to ETC	None 🗸	None 🗸
Application \	Problematic Setup		
() ()	comm device serial number does not match to defined	None 🗸	None 🗸
Application \	Consumption Import		
(j) I	lismatching data	e-mail 🗸	
ETC Event Lo	g \ Self-update		
(j) F	TC SETUP	None 🗸	
ETC Event Lo	g \ Run-time Error		
<u>A</u> F	TOS Kernel error	None 🗸	
Event Log \ (omm. activity		
8 0	iritical error	None 🗸	
(X) F	ACTORY SETUP	None 🗸	
Power Qualit	y \ PQ IEEE1159		
() (licker Severity	None 🗸	
Power Qualit	v \ EN50160-2007 Standard		

Once configured, the system ensures immediate email notifications when these events take place.

Image 15: configuring notifications

Comparing Similar Pumps or Stations

To do so, within Expertpower navigate the path MANAGER > DASHBOARD > ANALYSIS > COMPARISON. Here, users can conduct a comparative analysis of similar pumps or motors with regard to their energy consumption.



Image 16: graphic comparison

Thorough Analysis and Energy Visualization

In this module, the user gains insight into the pump's energy usage through the Detailed View & Heat Map. This enables assessment of consumption patterns, enhancement of energy efficiency, and prompt identification of the optimal load utilization.



Image 17: financial analysis

Weekly Distribution, kW	ſh							Heatn
_	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Avg.
00:00 - 01:00	149	168	146	134	133	168	161	151.29
01:00 - 02:00	154	159	135	126	132	162	160	146.86
02:00 - 03:00	149	158	128	121	134	159	159	144
03:00 - 04:00	147	125	131	122	133	159	154	138.71
04:00 - 05:00	151	123	126	120	131	154	158	137.57
05:00 - 06:00	147	126	126	122	129	157	158	137.86
06:00 - 07:00	237	193	178	181	175	155	155	182
07:00 - 08:00	364	288	286	261	270	163	158	255.71
08:00 - 09:00	440	337	335	335	342	160	158	301
09:00 - 10:00	488	368	368	374	346	163	161	324
10:00 - 11:00	498	385	380	389	373	174	164	337.57
11:00 - 12:00	504	398	386	393	402	166	163	344.57
12:00 - 13:00	506	398	385	396	397	174	160	345.14
13:00 - 14:00		404	397	408	400	176	162	351.86
14:00 - 15:00		416	399	411	405	179	166	354.57
15:00 - 16:00	489	412	401	403	398	178	162	349
16:00 - 17:00	492	397	393	406	393	180	168	347
17:00 - 18:00	473	382	373	379	359	174	164	329.14
18:00 - 19:00	401	330	308	343	289	172	157	285.71
19:00 - 20:00	254	219	203	211	204	170	157	202.57
20:00 - 21:00	195	164	167	143	142	167	155	161.86
21:00 - 22:00	181	150	155	145	144	162	155	156
22:00 - 23:00	176	152	137	136	139	162	153	150.71
23:00 - 24:00	172	148	136	135	135	160	152	148.29
Ava.	324.54	266.67	257.46	258.08	254.38	166.42	159.17	

Image 18: consumption heat-map

Strategic Overview with Executive Dashboard

The Executive Dashboard enables effortless monitoring of pumping loads. It facilitates simple comparison for energy efficiency initiatives, such as upgrading motors from EFF2 to EFF3 and EFF4. As a result, users can consider replacing or optimizing pumps to enhance overall efficiency.



Image 19: executive dashboard

Conclusion

Further to the steps indicated above, users can enhance energy management, minimize equipment malfunctions, and boost production efficiency. This applies regardless of the pump's specific application.

Examples of potential pump applications include (but are not limited to) the following:

Water Utilities: Pump motors are indispensable to water treatment and distribution systems. They extract, treat, and deliver water to homes and businesses.

HVAC Systems: Pump motors in HVAC systems circulate coolants or refrigerants to regulate indoor temperatures.

Agriculture: Pump motors are vital to irrigation systems, ensuring that crops receive adequate amounts of water for optimal growth.

Oil and Gas Industry: Pumps drive fluid transfer in refineries, pipelines, and drilling operations.

Construction: Powerful pumps transfer liquid concrete at controlled rates in concrete pumps.

Wastewater Treatment: Pumps transport sewage to purification facilities for treatment.

Marine Industry: Pumps handle bilge pumping activities, ballast control, and cooling systems on ships and boats.

Mining: Pumps drain mines and transport mineral-laden slurry during extraction.

Food and Beverage Industry: Pumps transport liquids for processing in food and beverage production.

Chemical Manufacturing: Pumps transfer chemicals between processing stages in chemical plants.