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Innovations & Best Practices for monitoring Pressure in Hydropower stations

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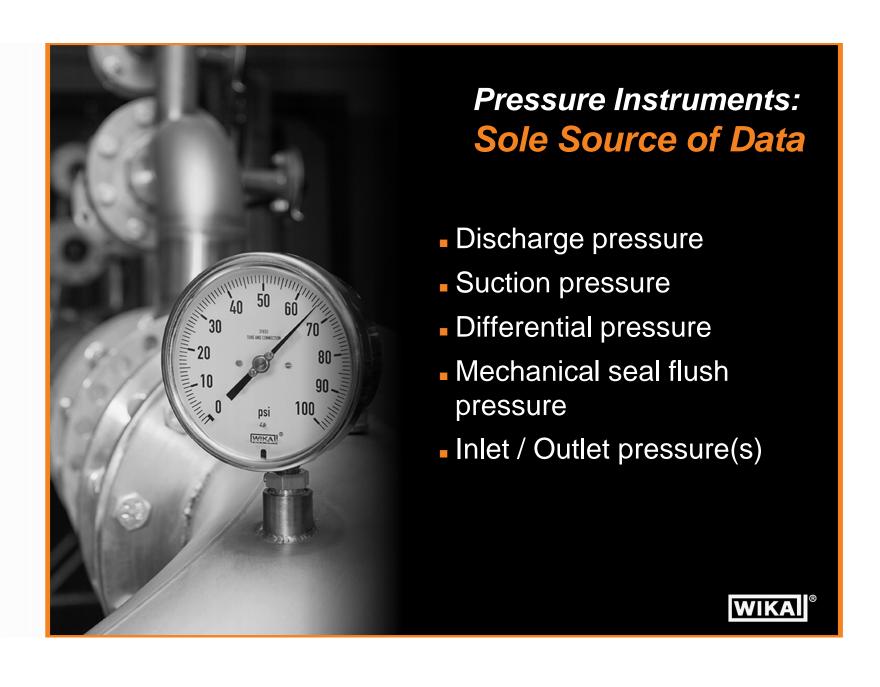
Pressure Instruments – Gauges, Switches, Transmitters









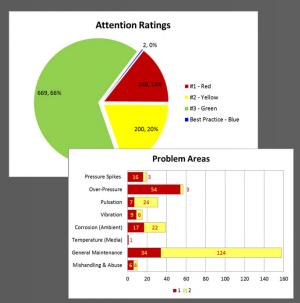


Hydropower Plant Example

- 1 FAST engineer onsite 3 days
- 373 Gauges / Instruments Recorded
- 49 Reds / 66 Yellows
- Overpressure and General Maintenance were top concerns
- Reduced unique models from 160 to 57 a 64% SKU reduction
- Plant standards created for materials and ranges
- New standards incorporated into SAP







$\overline{}$				full Scale	Operating	_	_	_			
AC31 F24	Concessoration	Gauge Tag	Gause Description	Pressure	Pressure	Warrant Practy	Connection	Operating Condition	Persile	Part Number	Walk Partition
Author	Operating time	Gauge rag	2.5" Unknows 2XX.53; 5/6" NPT	PLENTAGE	Pietros	minute Park	CONTRACTOR	opromycownos	Confirm Pressure Range, Window	Patracture	waxeenages
	oo	Story Task - Small Vermus	Connection	Uninous	Historian	Orajolecy Steal	107107	General Maintenance	Covered	9933549	303 SR 7 S 2009 S 1011
	LIU.	AUTO LANCE AND LANCE	65" Advort 1276 Disehrsen	GILLIGHT	CHARLOWS	ALCOHOL SEPT.	AN INF	Green Martinians	Comps	00.00.000	AL M 21 MAP I DEL
	oo o	Strong Acid Hd To Ry	Seal, Type , Connection	160	20	Stainless Steel	1/2"NPT	Acrestable		52412385	283. Nr 4.5 160PS 1/2 L M990 FCKNSR GF
			65" Adopt 1279, 1-0" NPT	-	-						
	oo o	Lime Silio	Connection	60	5	Stainless Steel	1/2"NPT	Acceptable	Mild Pulgation	9836015	293.96 6.5 10099 1/21
			6.5" Ashcioft 1279, 1,0" NPT								
2	GC C	North Ry Top NZ (1)	Connection	30		Stainless Steel	1/2"NPT	Mish and ling & Abuse	Window Cracked	9832999	293.36 4.5 3095/1/21
			6.5" Ashcroft 1279, 1/0" NPT								
- 2	GiO .	North Ry Top Hant Air	Connection	200		Stainless Steel	1/2"NPT	Acceptable		9836581	283.86 4.5 200PSI 1/2 L
			6.5" Ashcroft 1279, 1/0" NPT						Confirm Pressure Range; Gauge		
	GiO .	North Ru Top NZ (2)	Connection	Unknown	Unknows	Stainless Steel	1/2"NPT	General Maintenance	Covered In Debris & Valve Russed	9834049	293.36 4.5 300PS 1/2 L
			ES" Ashcroft 1276; 1/0" NPT Connection	160	Own		1/2" NRT			0034521	
_	GCI	Filtrers By GDSDt	Connection 6.5" Ashcort 1279, 1/0" NPT	160	Over	Stainless Steel	1/2"NPT	Over-Pressure	Pointer Pegged	9636261	293.36 4.5 200PS 1/2 L
	oo	G1Pv 6 Discharge	ES" Ashciaft 1279, 1/0" NPT Connection	200	14	Stainless Steel	1/2"NPT	Acceptable		9636069	283 Nr 45 800P9 1/2 L
	CACI	GIPL S Discharge	Lonnection 4.5° Automobi 1779; 1,75° MBT	200	14	SCANNECS SCHOOL	1/2-1071	Aceptable		MERCOCK	265 M 65 MBPH 1/21
	oo	GSPV-N Discharge	Connection	200		Money	1/2"NPT	Acceptable		4279479	263.364520099121
	CAU.	Mary W. Lincolnings	A ST Authority 1979 A DT NRT	- 200	-	MACHINE:	42 MFI	Nathrana		52.0918	285.88 E3 200° S Q 21
	oo o	SOPy 5 Discharge	Connection	200		Orajolecy Speet	1/2"107	Acceptable		0034549	203 Nr 4.5 200P9 1/21
			65" Ashopit \$2% 10" NPT								
	oa o	SOPy N Discharge	Connection	200		Stainless Steel	1/2"NPT	Acceptable		9836085	293.36 4.5 2009/9 1/21
			6.5" Ashcioft 1279, 1,0" NPT								
- 2	caci	GOP u-G13Pu Seal Water Supply	Connection	160	20	Stainless Steel	1/2"NPT	Acceptable		9834581	283 Nt 4.5 200PSI 1/2 L
			6.5" Ashcroft 1279, 1/0" NPT								
2	caci	Filter By 602ST	Connection	1000	Selow Zero	Stainless Steel	1/2"NPT	Acceptable	the Compound Gauge?	9834275	293-36 4.5 1000PSI 1/2 L
	nn.		6.5" Ashcraft 1279, 1/0" NPT Connection	m	100	Orajolacy Orași	1/2" NRT			0034540	
2	aa	GCOP u-S Discharge		300	100	Stainless Steel	1/2"NPT	Pulation		9834549	293.36 4.5 300P9 1/2 L
			6.5" Ashcon't 1279, 1,0" NPT	200			1/2"NPT				
	CaCl	G18° 4 Stischarge	Connection 6.5" Ashcor's 1279, 1-Q" NPT	200	,	Stainless Steel	1/2-1071	Acceptable		9834049	293.36 4.5 300PS 1/2 L
	oo	GLEV N Discharge	Connection	200	16	Stainless Speet	1/2"NPT	Acceptable		9934721	203.00 4.5 2009/0 1/2 L
	Lau.	MARKET MANAGER	Lonnection 4.5° Automobi 1779; 1,75° MBT	-20	- 4	mannes/, 30661	es mrl	PARTHUM		10,000	AND DESCRIPTION OF STREET
	on o	GOP's Discharge	Connection	160	30	Orajolecy Steal	1/2"107	Acceptable		0034521	203.06.4.5.200P9 1/2 L
			45" Ashooft \$2% 1/0" NPT	-80	- 20	The same of the same of		, many man			
	oo o	GOSCT Probail Purps Water Supply	Connection	160	90	Stainless Steel	1/2"NPT	Acceptable		9836281	203 Nr 4.5 200P9 1/21
			6.5" Ashcoft 1279, 1,0" NPT						the Compound Gauge? & Pointer		
2	GC C	GIP.	Connection	160	Selow Zero	Stainless Steel	1/2"NPT	Pressure Spikes	Becc	9834031	293.36 4.5 200P9 1/2 L
			6.5" Ashcor's 1279, 1,0" NPT								
- 2		G19°s Discharge	Connection	300		Stainless Steel	1/2"NPT	Acceptable		9834049	293-36 4.5 300P9 1/2 L
		Disphragm Pump Behind North	6.5" Ashcroft 1279, 1/0" NPT						Safety Glacc Pulcation From		
2	caci	Clarifier	Connection	360	80	Stainless Steel	1/2"NPT	Pulation	Diaphragm Pump	9836081	293.36 4.5 200PSI 1/2 L
			6.5" Ashcos/t 1279, 1,0" NPT								
- 3	Ga C	North Clarifier Plant Water	Connection 6.5" Ashcor's 1279, 1-Q" NPT	200	90	Stainless Steel	1/2"NPT	Acceptable	Mild Pulgation	9836031	293.86 4.5 200Pil 1/2 L
	oo	GZIPu-A Discharge	ES" Ashciaft 1279, 1/0" NPT Connection	***		Stainless Steel	1/2"NPT	Acceptable		0034745	293. Nr 4.5 100P9 1/2 L
	COLU.	parameter or annual spirit	(CONTRACTOR)	- 20		(#1400 Scenario)	MA MAL	marquare		neal(II)	AND DESCRIPTION OF STREET

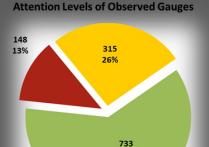
Another Hydropower Case Study

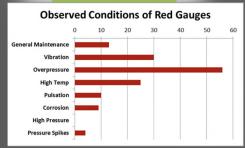
- 2 FAST engineers onsite 2 days
- 399 Gauges / Instruments Recorded
- 48 Reds / 105 Yellows
- Overpressure and Vibration were top concerns
- Created standards for hazardous material lines
- Implemented features and visual distinctions for various criticality levels



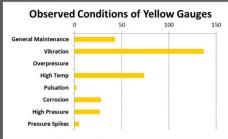






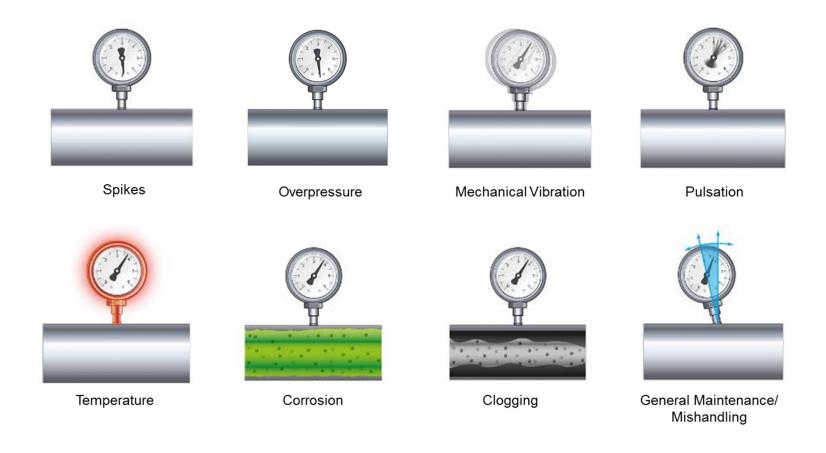


61%



Best Practices:

Let's start with most common failure conditions

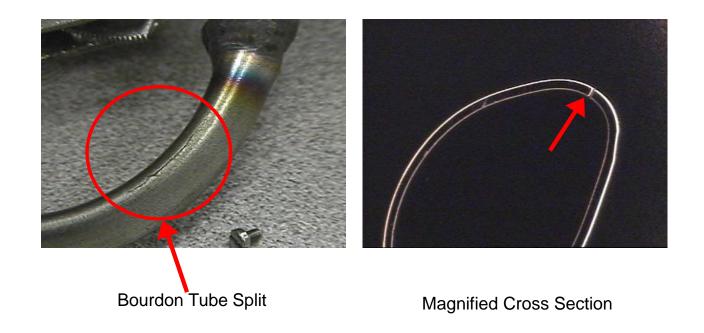


Pulsation – Symptoms & Analysis

- Caused by media rapidly cycling the pressure gauge.
- Increases wear on internal components and Bourdon tube.
- Difficult to read pressure due to pointer flutter.
- If the pointer pulsation increments are greater than 5% of full scale value, you must intervene to prevent damage to the gauge.
- Types of pulsation
 - Centrifugal high frequency, low amplitude; causes extreme pointer movement, usually contained to small pressure increments.
 - Reciprocating low frequency, high amplitude; causes rapid pointer movement, may fluctuate over larger pressure increments.



Failure – Dynamic (cyclic) Load From Pulsation



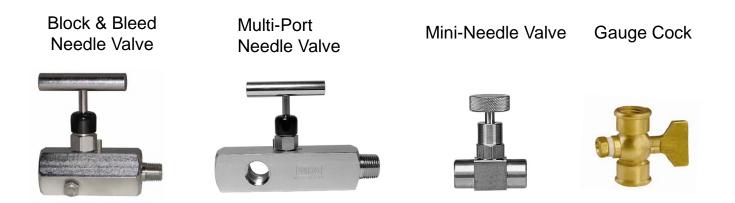
Best Practice - Pulsation

- Socket restrictor Allows pressure to equalize slowly. Economical and low cost solution.
- Liquid filled case Dampens pulsation. Lubricates and cools moving parts.



Best Practice - Pulsation

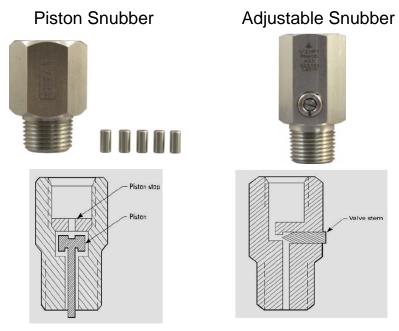
- Needle valves and gauge cocks can be used to throttle down pressure pulsations.
- During periods of extreme pulsation, needle valves and gauge cocks can be used to isolate or block- off the instrument.



Best Practice - Pulsation

A liquid-filled case and a restrictor will resolve most pulsation problems, but extreme pulsation requires the use of a snubber.

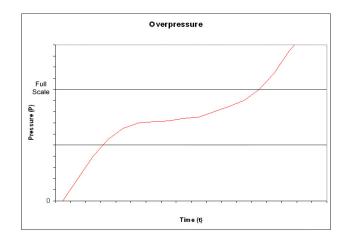
Porous Snubber

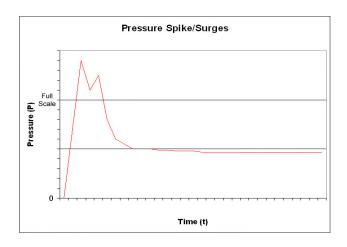


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Overpressure and Spikes – Symptoms & Analysis

- In general, an overpressure failure is caused by the application of a pressure greater than the rated capacity of the measuring element.
- In some cases ultra fast (*msec*) pressure increases can cause the pressure element to fail well before its "rated" rupture pressure.





Overpressure and Spikes



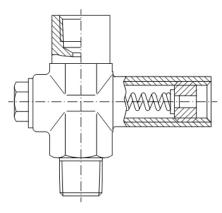




Bourdon Tube Warped & Split

Best Practice – Overpressure and Spikes

- At a predetermined pressure, the overpressure protector "shuts-off" pressure to the gauge, preventing damage to the sensing element and protecting the calibration.
- The set-point is externally adjustable. Overpressure protectors generally feature a piston valve which is designed to dampen system pulsation.





[23.06.2023]

Temperature – Symptoms & Analysis

- Excessively high media temperatures:
 - Place additional stress on the measuring system which can reduce its operating life.
 - Cause components of the pressure gauge to break down and erode (window material, gaskets, dial, etc).
 - Can cause the pressure system to fatigue and rupture.



[23.06.2023]

Best Practice - Temperature

■ Ensure that ambient and media temperatures are within allowable temperature limits of the gauge.

Excessive temperature applications may require the use of accessories or diaphragm seal solutions.

■ In addition to Stainless Steel Gauge:

- Long Pipe (6" to 12")
- Siphon
- Cooling Element
- Cooling Tower
- Capillary
- Diaphragm Seal



Corrosion - Symptoms & Analysis

Corrosion failure occurs when process media is not compatible to the wetted parts material of the pressure gauge.



Holes in Bourdon tube

Hole in Bourdon tube

Corrosion - Symptoms & Analysis

Corrosion failure not only occurs from media attacking the wetted parts, but also from corrosives in the environment attacking the case, window and gauge internals.



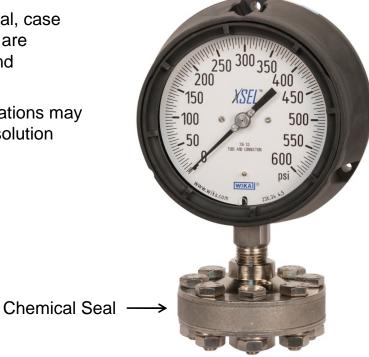
Corroded Dial



Fogged Window

Best Practice - Corrosion

- Ensure that the wetted parts material, case material and internals of the gauge are compatible to the process media and atmospheric conditions
- Excessively corrosive media applications may require the use of diaphragm seal solution

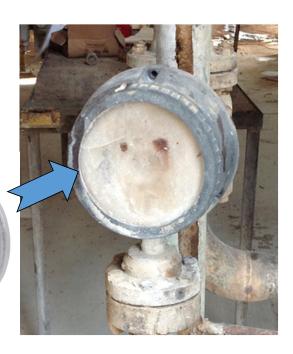


General Maintenance

 General Maintenance - Heavy Build-Up on Instrument housing

 Utilizing process instrument covers can save time and expense; extend lifetime





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Selection / Configuration of Pressure Instruments

- Pressure media composition (compatibility, clogging, crystallizing, etc.)
- Pressure media temperature
- Ambient conditions (temperature and corrosives)
- Pressure range (2 X normal operating pressure)
- Conditions affecting wear of the system (pulsation, vibration, shock, etc.)
- Method of mounting (stem mount, etc)
- Required accuracy



39.6% of pressure gauges reviewed in refineries or chemical plants have failed or are in danger of failing.

Typically 30% in hydropower systems could be similar or much higher. Do you know if your gauges have failed or near failure?

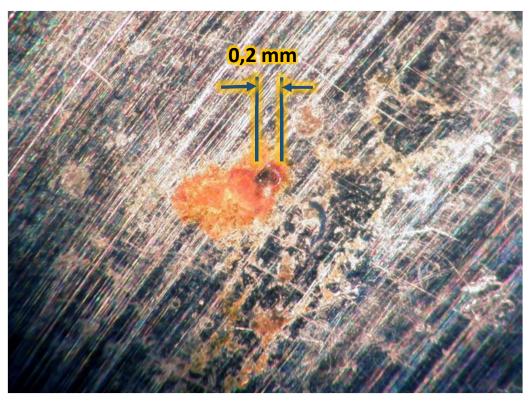
Best Practice / Innovation on Pressure Instruments

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Mechanical Pressure Gauge Selection 2020

Pressure transmitter damage?



Destruction of the diaphragm via pitting corrosion



Mechanical damage

Innovation: Diaphragm Monitoring =>

reduced failure risk

• Design -

measuring instrument

diaphragm seal with double diaphragr

Monitoring element

Monitoring element

Local indication

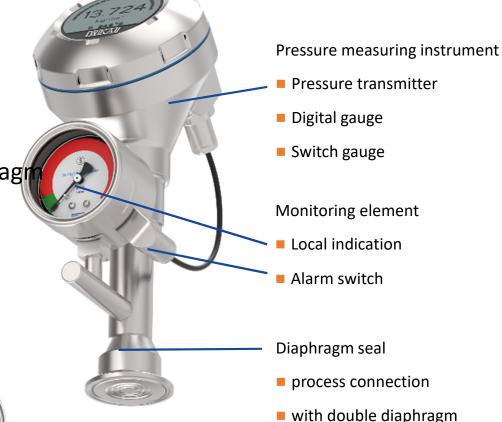
■ Pointer in the green area: OK

■ Pointer in the red area: Diaphragm break!

Alarm switch

■ Failure mode signal: Output 3.5 mA

HART status (Diaphragm rupture)



Innovations in Pressure Measurement

- Electronic differential pressure measurement
- Connectivity Bluetooth , USB
- Battery powered















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