ASIA TURBOMACHINERY & PUMP SYMPOSIUM
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Investigation of unexpected Trips in Steam Turbine

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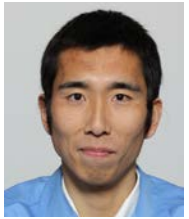

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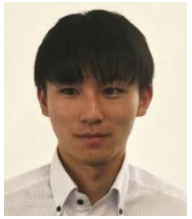

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Abstract

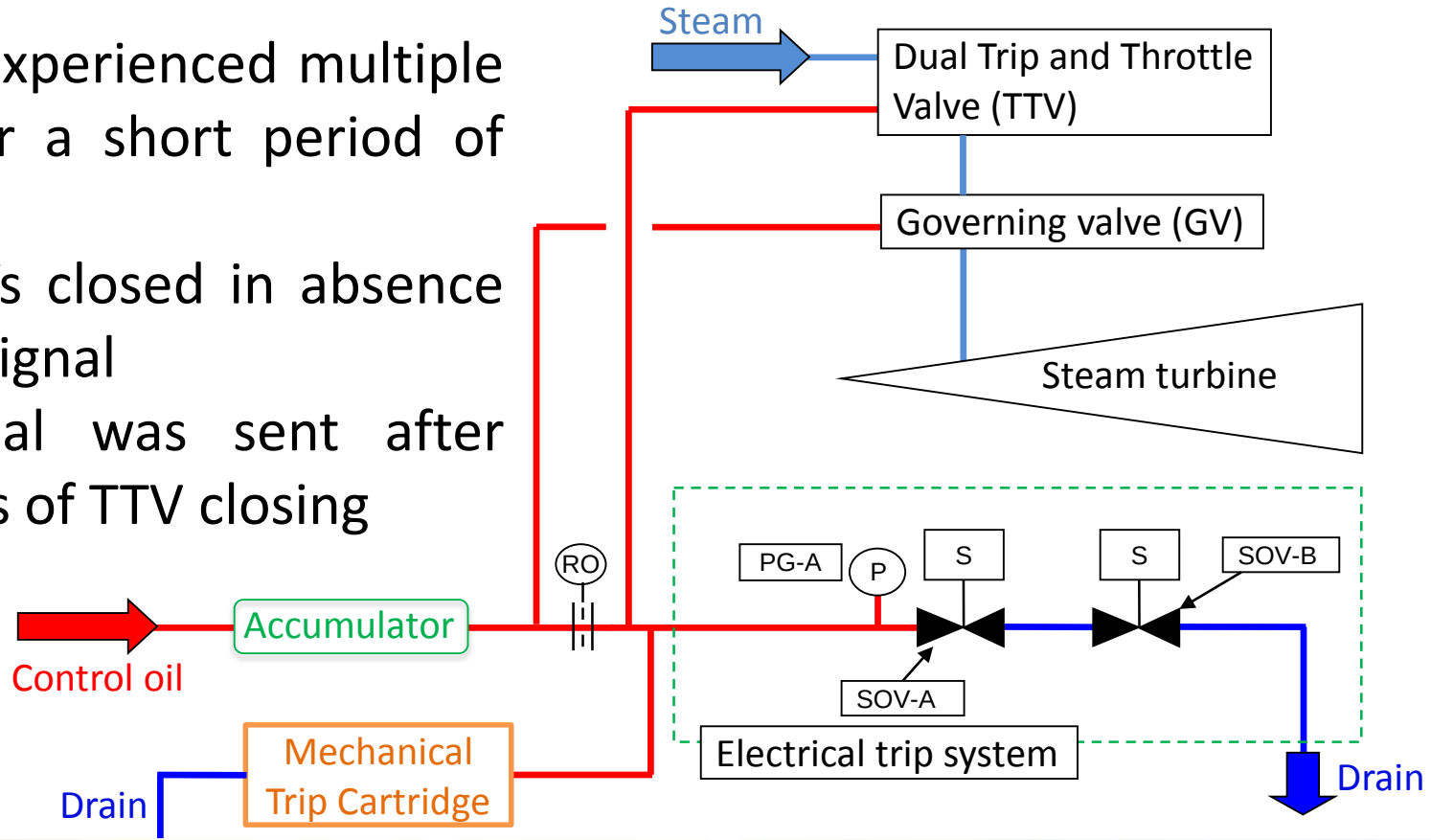
A 56 MW steam turbine tripped several times over a short period of time although the trip signal was not sent.

A thorough examination of the turbine at site ruled out any problems with the trip system. The pressure data for control oil line indicated a sudden drop in oil pressure forcing the trip button in trip relay system to move to the trip position. Dynamic simulation of the trip system was carried out to find the effect of various factors including the abnormal behavior of different components.

This presentation shows the detailed analysis results, possible causes of failure of the trip system and solution employed to solve these problems.

The Problem

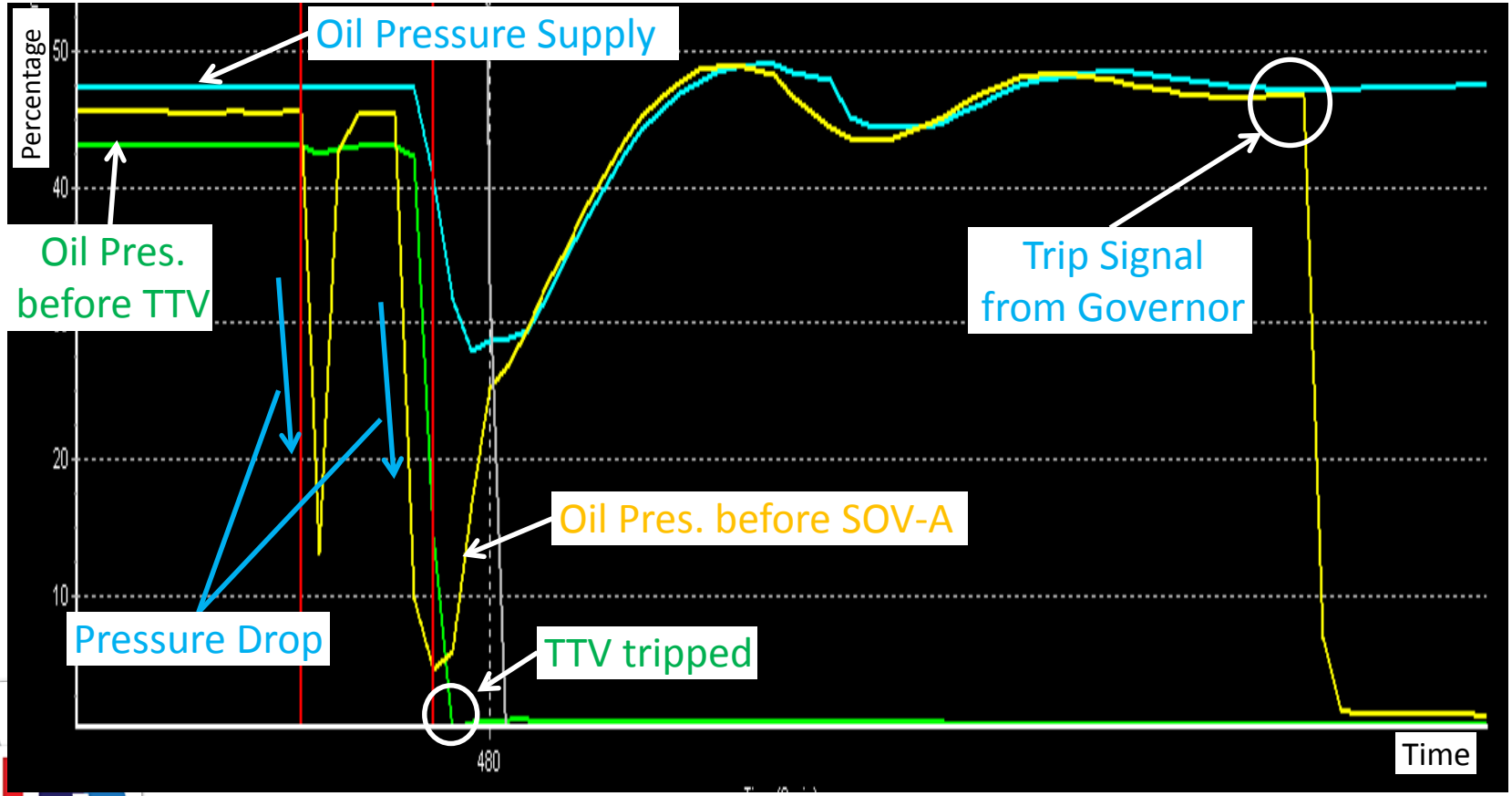
- Turbine experienced multiple trips over a short period of time.
- Both TTVs closed in absence of a trip signal
- Trip signal was sent after 3 minutes of TTV closing



Troubleshooting

Problem	Possible Causes	Possibility
Unexpected trips	SOV malfunction	Low
	Unstable Trip Signal	High
	Fluctuation in oil pressure due to sudden increase in GV oil consumption	High
	Abnormal release of Trip pilot piston in trip relay system (Mechanical Trip Cartridge)	Low

Trend Data

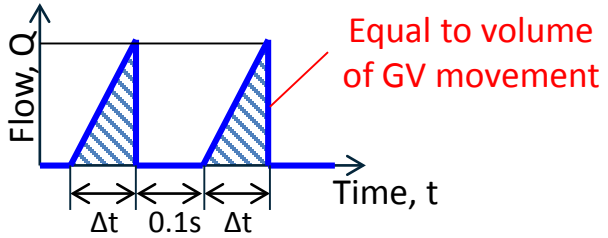

Percentage
50
40
20
10
480
Time
Oil Pressure Supply
Oil Pres. before TTV
Trip Signal from Governor
Oil Pres. before SOV-A
Pressure Drop
TTV tripped

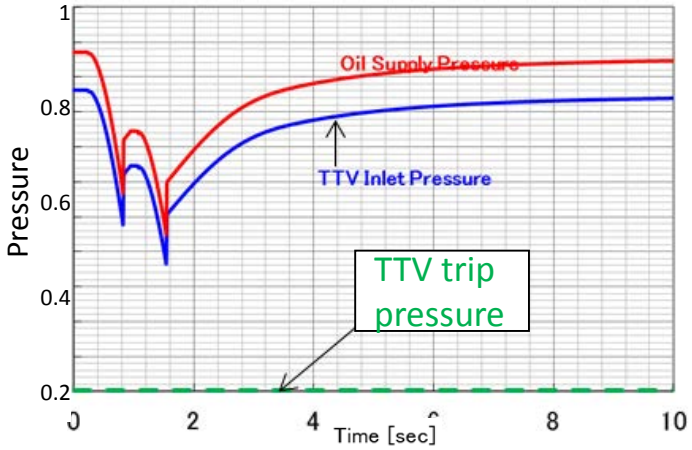
Trend Data

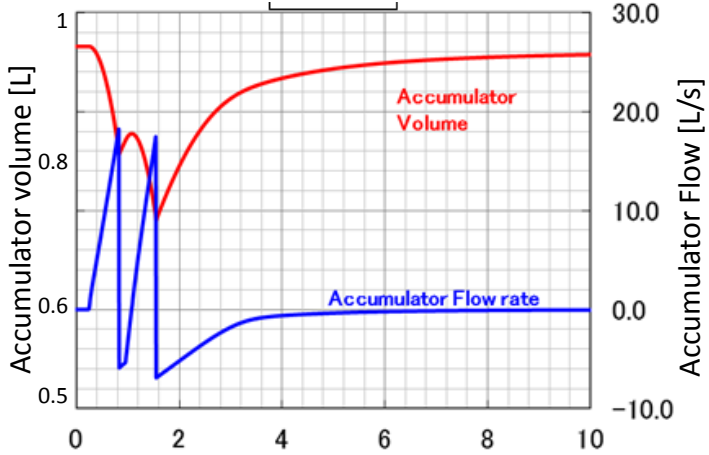
- Oil Pressure before SOV-A dropped for a few milliseconds before coming back to normal until the trip signal was sent
  - Trip Cartridge – No issue as oil pressure would have remained low (later verified by testing)
  - SOV Malfunction – Solenoid valve was tested and no errors were found out
  - Pressure drop (TTV trip) due to GV motion – Possible
    - ✓ Single Accumulator for GV and TTV line case
    - ✓ Separate Accumulator for GV and TTV line case
  - Unstable Trip Signal – Possible

Dynamic Simulation (GV motion)

Single Accumulator	Accumulator Initial Charge Pressure	G.V Stroke [%]	Stroke Times	Δt [sec]
	414 kPaG	48%	Twice	0.6



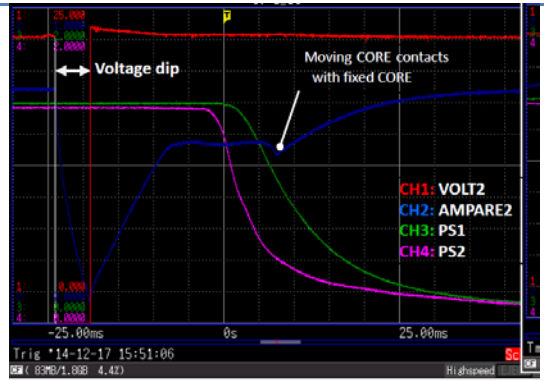




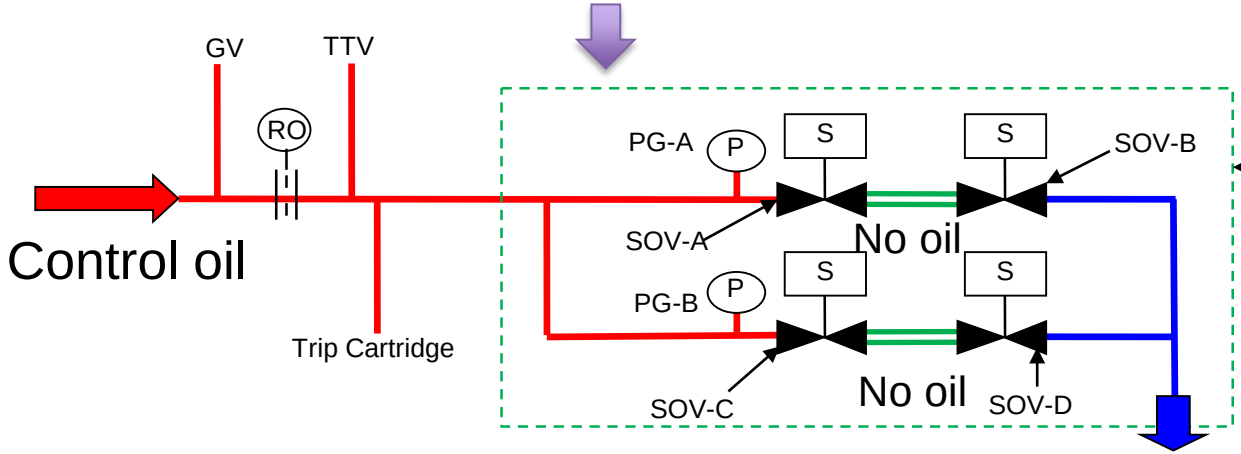
The oil pressure at TTV didn't decrease to TTV trip pressure when the Actuator movement was 48% of the maximum stroke in 0.6 sec. with initial charge pressure of 414 kPaG which means **sudden increase of GV oil consumption didn't trip the TTV.**

Unstable Trip Signal

Possible Scenario: Trip signal to the SOV-A dropped from 20 mA to 4 mA for few millisecond thus opening the SOV. Using SOV test, it was found that the trip signal longer than 5 ms will open the SOV.



From -24ms to -19ms (approx. dt=5ms), SOV got unlatched



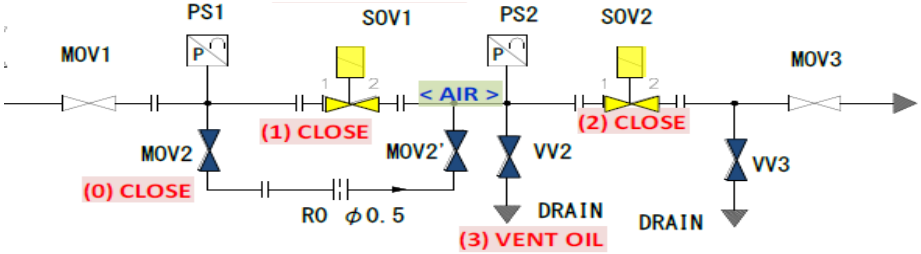
SOV seat: pilot type

High pressure difference across SOV -> Low leakage and vice-versa

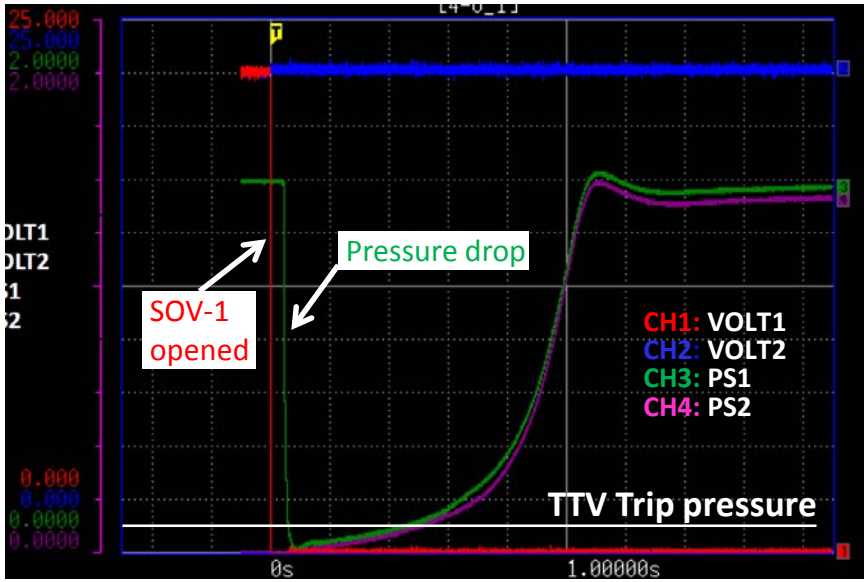
Initially, low quantity of oil is present between the two SOV, length of piping between SOV is larger than 600 mm. Due to oil leakage across SOV, the piping between the SOV has no oil left (atm. press.)

Unstable Trip Signal

Dynamic Simulation and testing was performed to study the effect of closing of SOV-A in the **absence of oil between the two SOV's**.



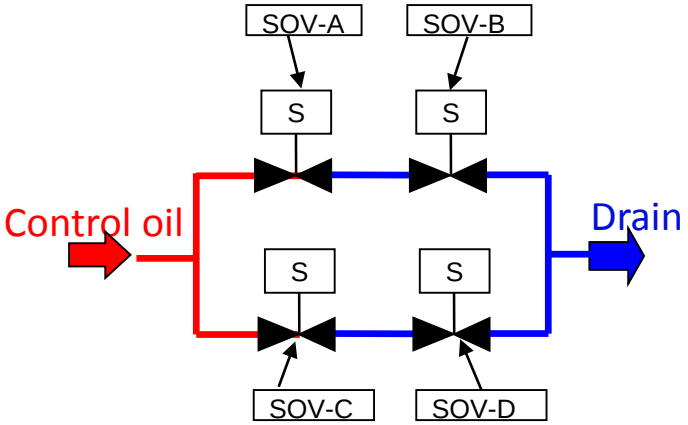
Simulation Schematic



Unstable Trip signal, SOV1 got unlatched. P1 and P2 dropped to 0.1 bar which tripped the TTV (TTV trip pressure: 4 bar). The pressure recovered in 1.2 to 1.5s as SOV-2 was still closed.

Unstable Trip Signal

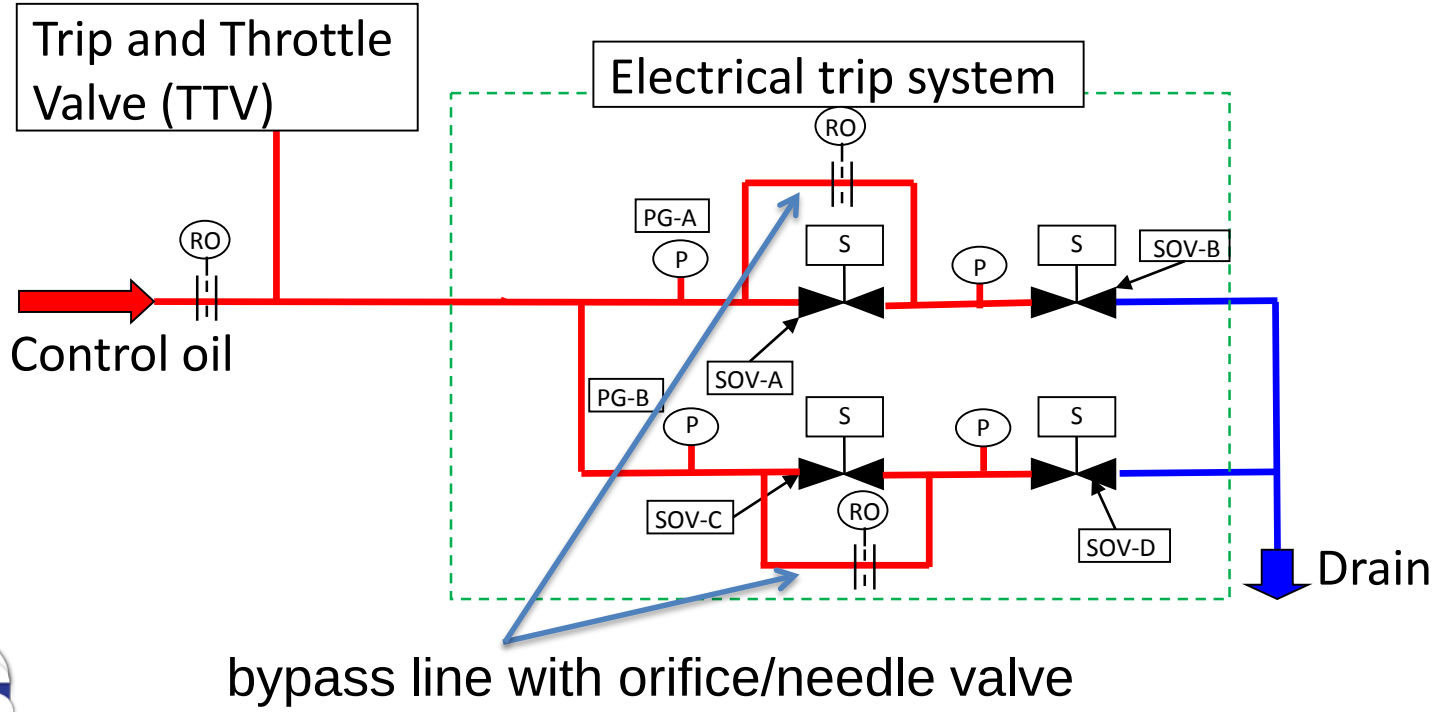
TEST RESULTS		
Test No.	SOV action	T.T.V
1	SOV-A and SOV-B open. SOV-C and SOV-D close.	Trip properly
2	SOV-A and SOV-C open. SOV-B and SOV-D close.	Abnormal trip (Trip system malfunction)



This simulated result matches the FLP577 Turbine pressure trend data with sharp recovery condition, it can be concluded that the main cause of instrument issue is unstable trip signal and absence of oil in piping between the two SOV's.

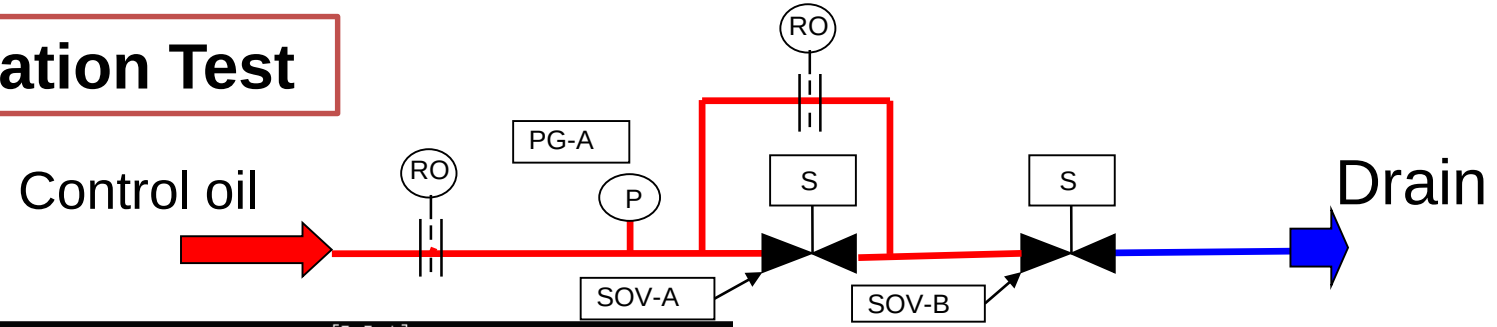
Countermeasures with test results

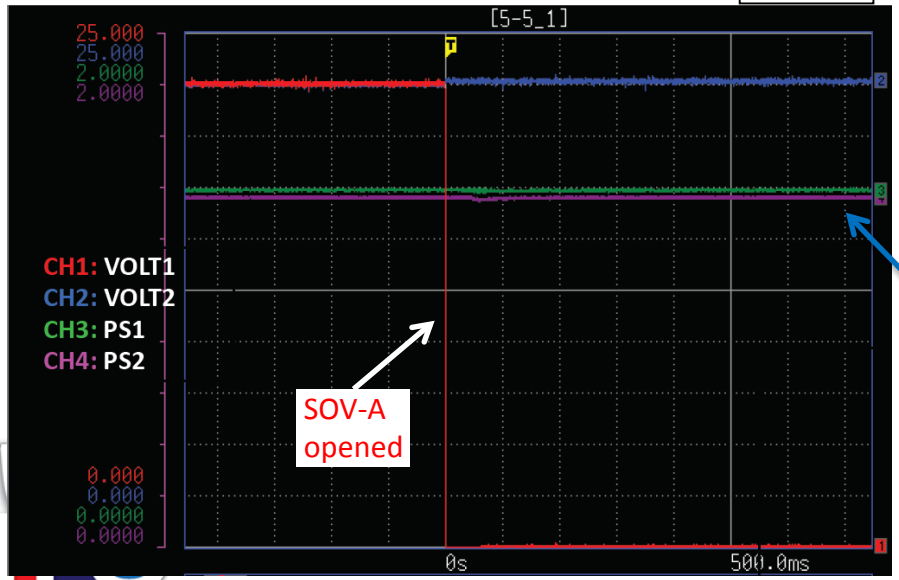
1. Adding a bypass line with orifice/needle valve to equalize the pressure before and after the SOV.



Countermeasures with test results

Verification Test





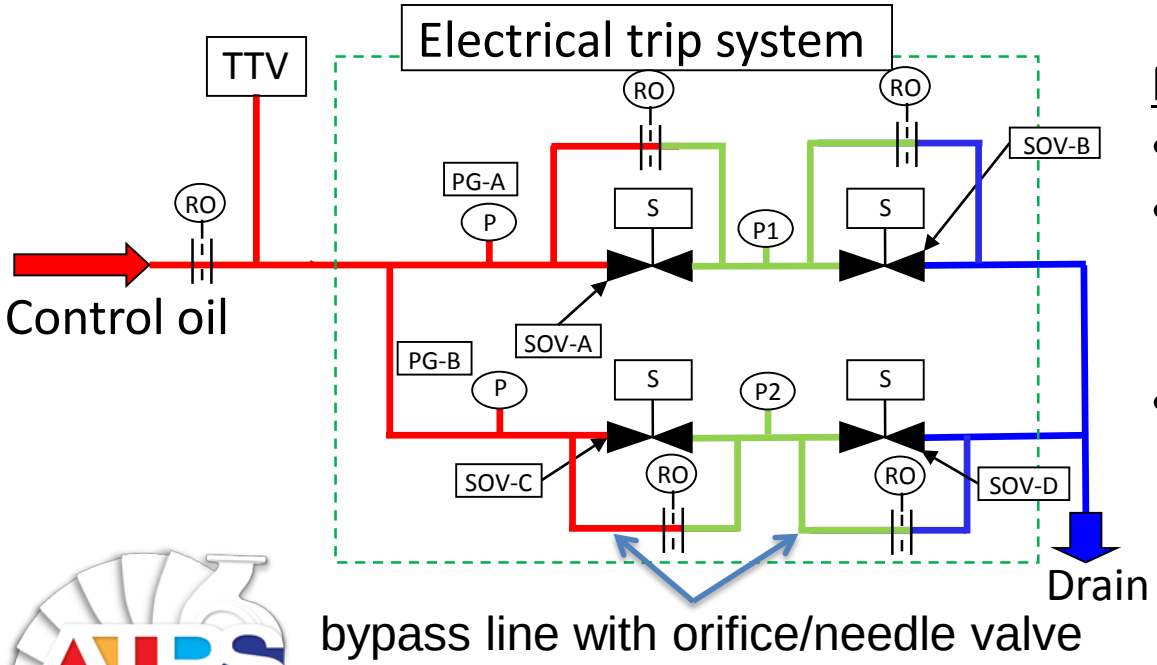
De-energized the SOV-A

<u>Result</u>

Pressure drop of PS1(green line) was almost zero.

Countermeasures

2. Adding **<u>bypass line across both SOV</u>** with orifice/needle valve to equalize the pressure before and after the SOV.



<u>Merits:</u>

- Prevents airlock in the system
- Oil flow keeps the drain line warm (lower viscosity and better performance)
- Configure alarms in DCS by comparing the line pressure PG-A and P1 with drain pressure to check SOV health

Lessons Learned

- This case shows how minor factors overlooked during the design stage can cause the Turbine to trip.
- Root cause analysis and Dynamic simulation is an useful tool in understanding the failure modes of trip system.
- SOV unlatch conditions should be studied in detail, 5 ms voltage fluctuation is too sensitive for the SOV to unlatch. It should be ensured that control/trip system don’t generate such voltage fluctuations.

Thank You…

Questions???