SLNG Terminal

Journey Towards Reliability Excellence

20 Apr 2023

Journey Towards Zero Reliability of Gas Supply Incident

Multiple systems driven by strong ownership, accountability and responsibility of the team

1. SINGLE POINT FAILURE

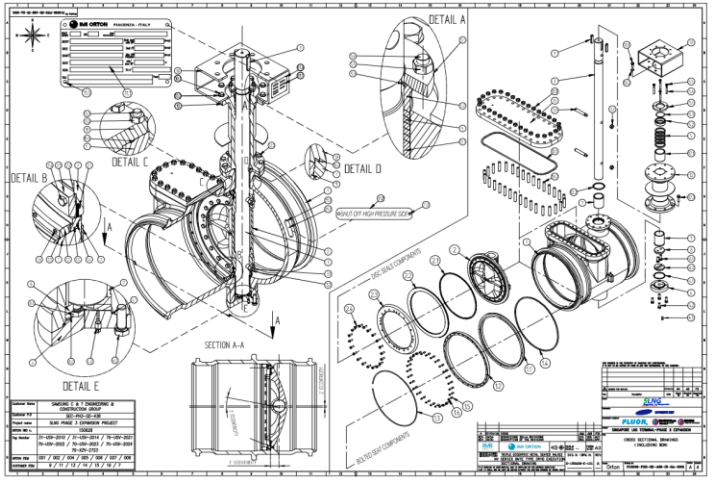
Single Point Failure Analysis

- Multi-disciplined team formed comprising of Process, Mechanical, Electrical, Instrumentation and Controls
- All equipment on the gas supply process identified for SPF analysis
- Failure modes and preventive measures identified to prevent equipment tripping

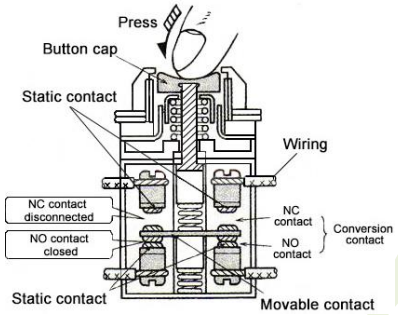
Examples of preventive measures

	System	SPF Analysis Preventive Measures
1	Open Rack Vaporizer/ Seawater	Implemented seawater flow, pressure and level 2oo2 voting
2	Booster Pump	Implemented booster pump flow, pressure and level 2oo2 voting to prevent spurious tripping
3	Electrical	Implemented redundant power for UPS control circuit

Reliability Excellence
Component Failure Analysis



- Identify components with exploded view drawings



- Identify components for 130 critical valves & ESD buttons
- Identify possible failure mode of components
- Identify causes of failure modes
- Identify mitigation measures to reduce risk of failures
- Implement Measures

- Actual finding match with analysis – deteriorated diaphragm can lead to Pipeline valve closure if not replaced

Tag number	Fail Action	Volume Tank with Pressure Monitoring	Valve OEM	Valve body Model Number	Valve type	Valve Size	Actuator Model	Pressure Monitoring Tag	Air regulator	Quick Exhaust Valve	External Filter	Pneumatic Valve	Flow regulator	Fail last relay	Flow port regulator	Check Valves
41-USV-2008	F.C	Yes	AMPO/POYAM	B.3.28" 12A	Ball-Top entry trunnion	28"600 BW	Rotork GP-200S	41PI2020	Bifold	Bifold S06-QEV	No	NA	Bifold S06-CPV-01	NA	Bifold S06-PFR	No

Component	Failure Mode	Failure Symptoms	Possible Causes	Likelihood	Recommendation
Quick exhaust valve	Diaphragm failure leading to external air leaking	Valve goes to fail close position	Rubber material failure, end of life	Occasionally	1. Replacement of diaphragm material every 5 years 2. Improve material to Viton 3. Evaluate the need for QEV

2. CONTROLS FOR RELIABLE OPERATIONS

Controls for Reliable Operations

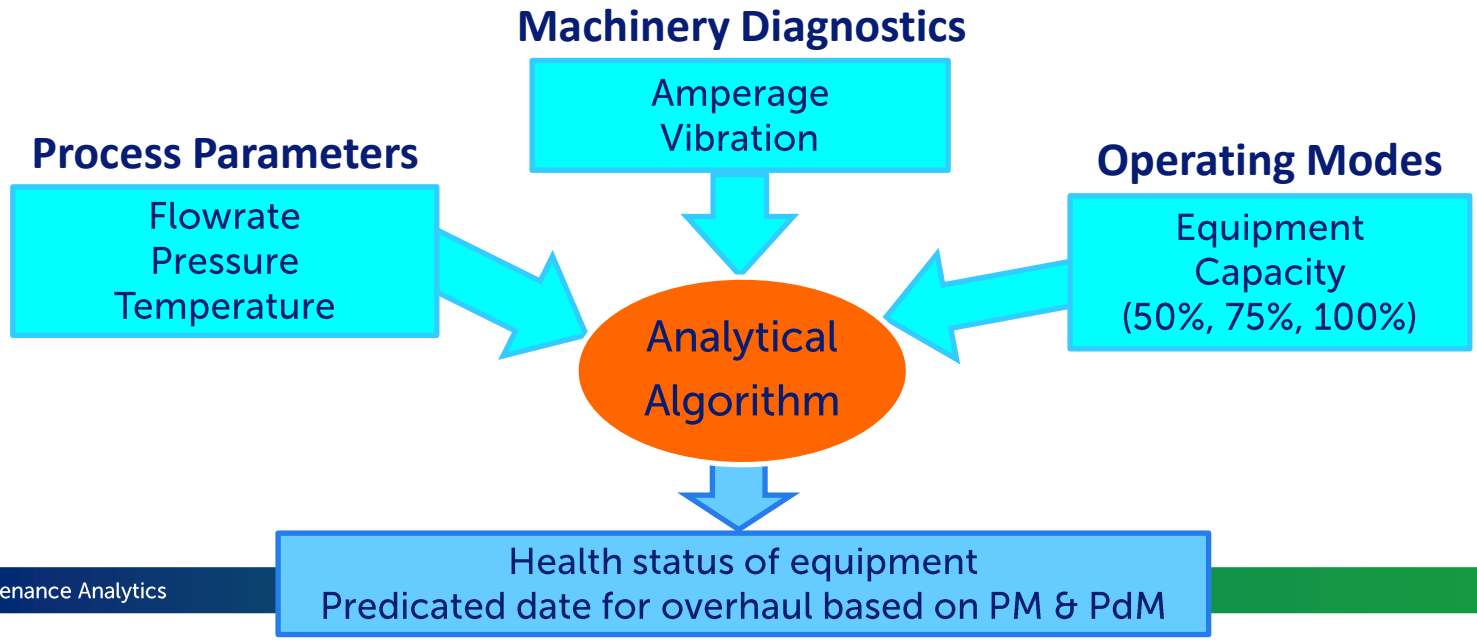
Utilize control logic to aid Panelman and enhance Reliability of Gas Supply

- **Flow Nomination Automation** for automatic distribution of flow set value to ORV and Metering Skid using Master Controllers in event of equipment trip for quick restoration of gas supply
- **Seawater low header pressure logic** to enable restoration of seawater flow to ORV and prevent cascading trip in event of seawater pump trip
- **Logics and operator guide** to prevent accidental selection to calibration or manual mode of critical to gas supply reliability controllers

3. DIGITALIZATION

Predictive Maintenance Analytics - Framework

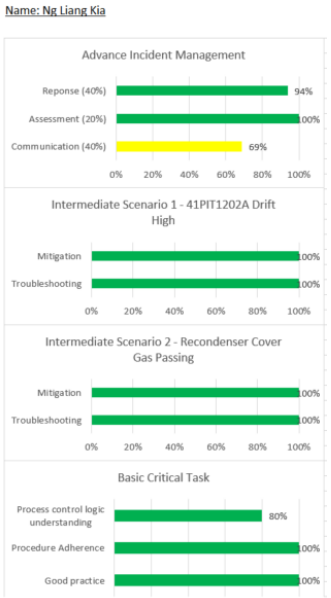
- Project is funded by National Research Foundation & managed through EMA
- A Predictive Maintenance framework using big data
- Enhance the reliability of SLNG critical rotating equipment
- Improve standardization, efficiency and accuracy of equipment health assessment and fault identification as the data (i.e Process, Mechanical, electrical) are co-related and integrated for a holistic evaluation
- Provide an insight of the parts required for next overhaul. Hence, parts can be made available in advance to avoid extended downtime.

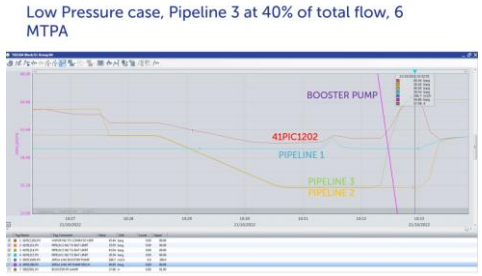


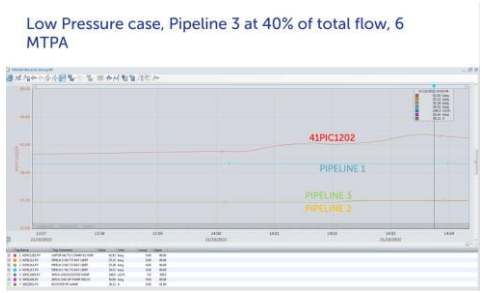
4. MANPOWER CAPABILITY BUILDING

Operator Training Simulator

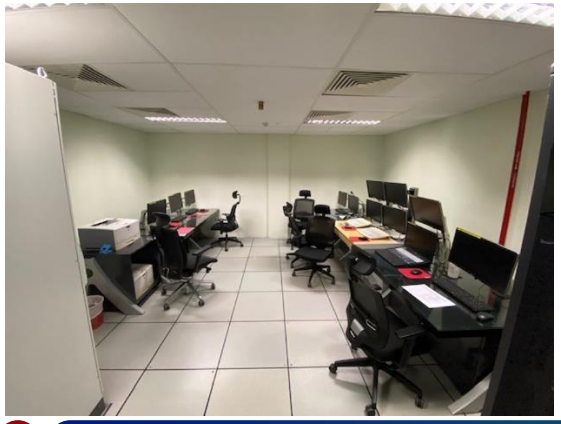
- OTS primarily used for training for Panelman & to perform process simulation for Process Engineers
- Developed structured OTS training and qualification program. OTS scenario training conducted every quarter
- Scenarios developed together with Panelman to recreate high stress environment during incident
- OTS upgraded in FY2022 to mimic actual control room environment



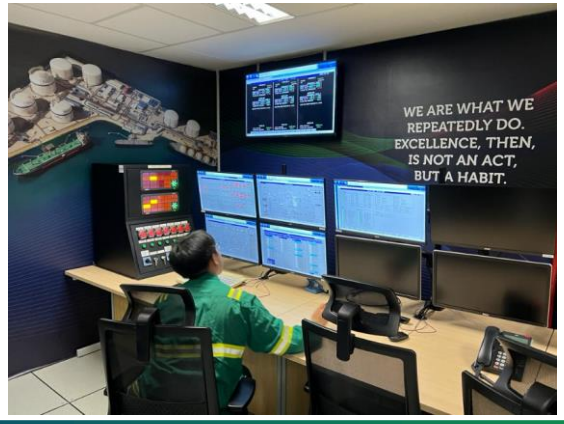




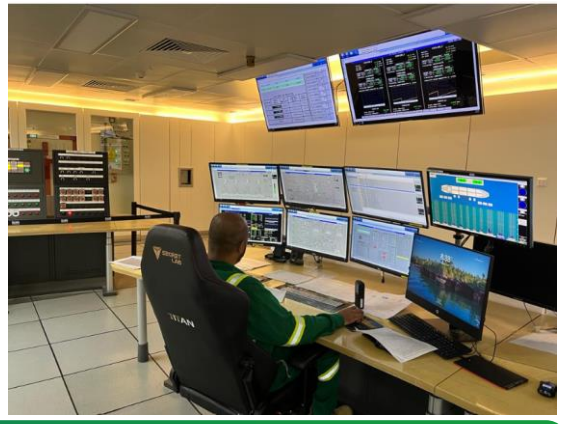
OTS Before Upgrade



OTS After Upgrade

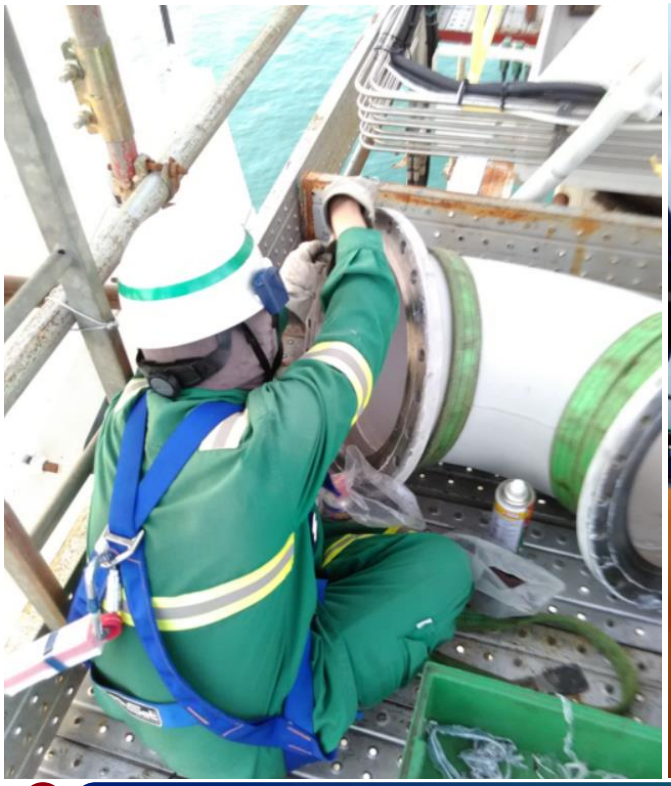


Actual Control Room

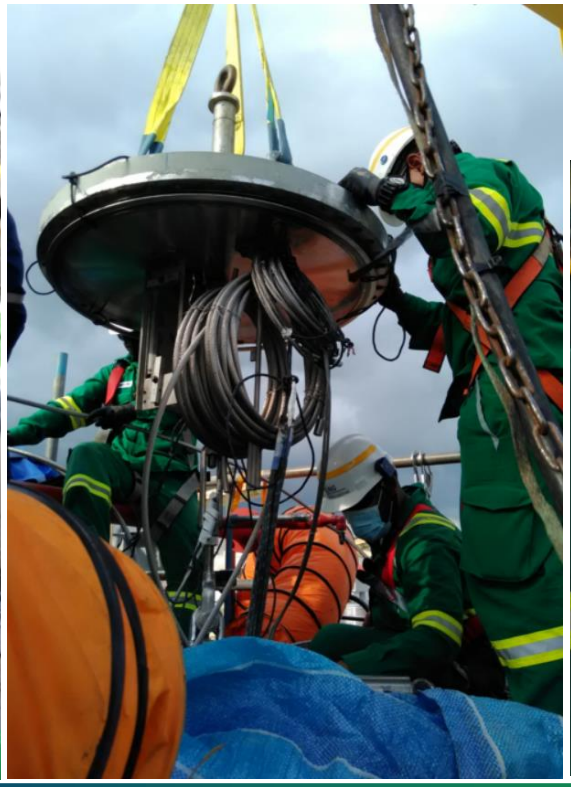


SLNG Operations Team acquired skills & experiences to perform critical equipment maintenance → Self Reliance & reduce dependence of OEM

Replacement of cryogenic seal for Marine Loading Arms



Removal, service and installation of In-Tank pump into tank

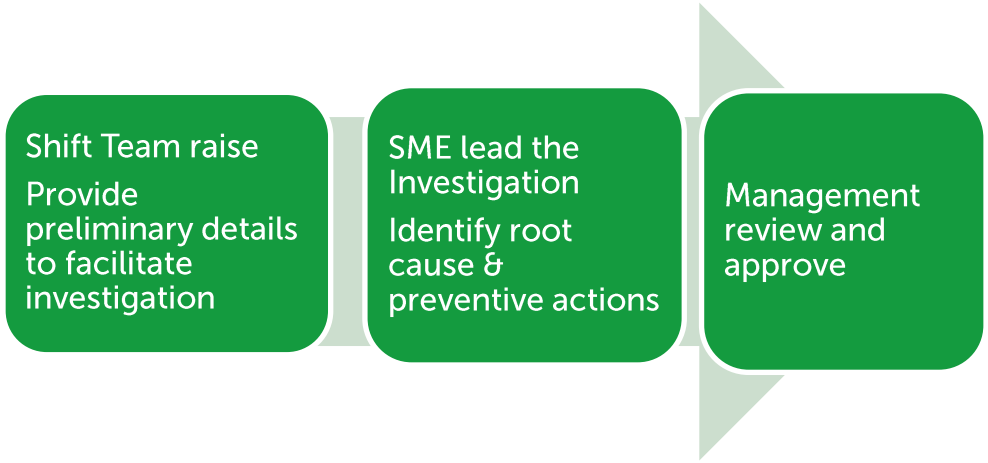


Removal, service and installation of Booster pump into well

5. OPERATIONS ABNORMALITY REPORT

Operations Abnormality Report

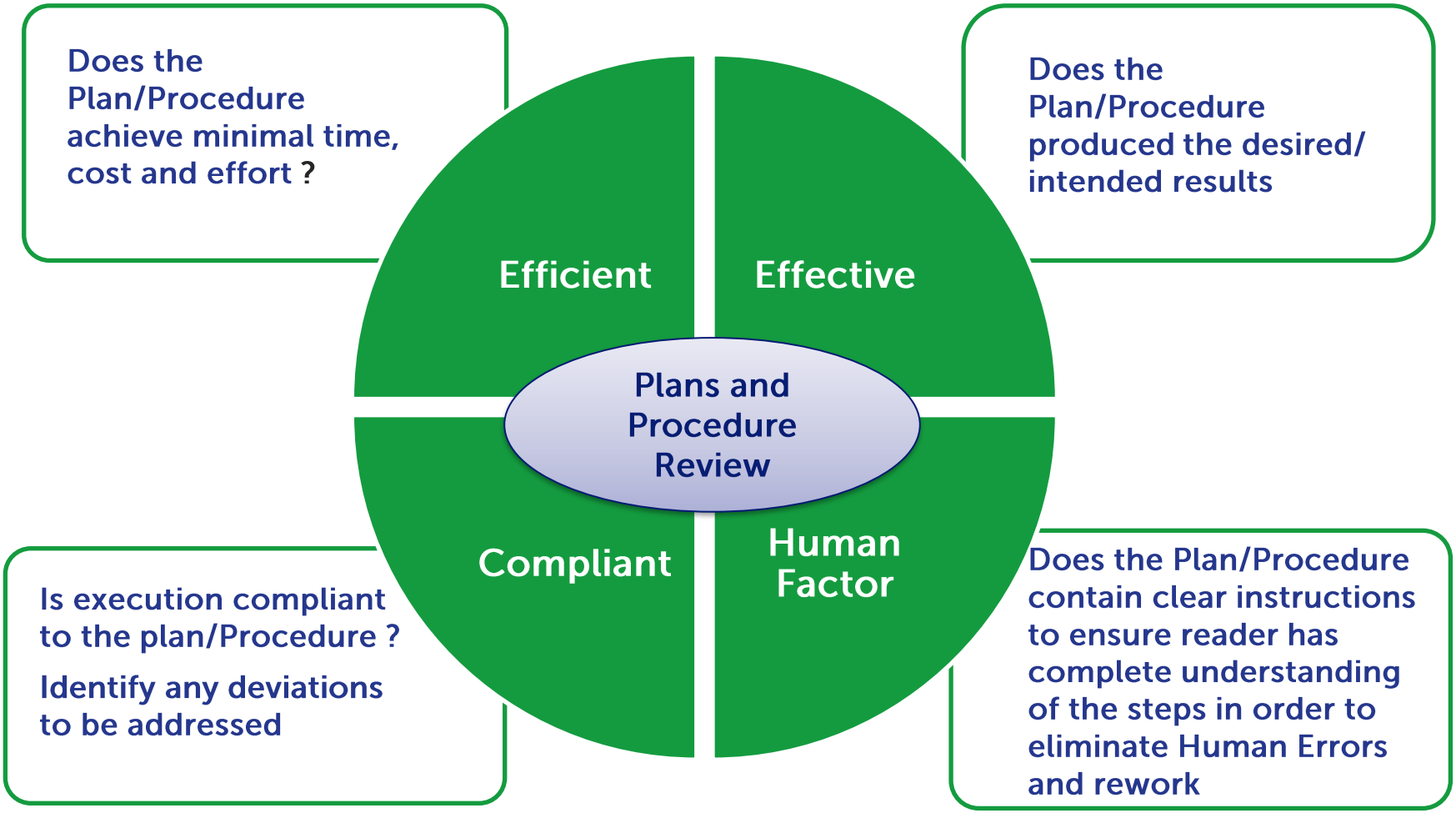
- For early identification and prevention of potential gas supply incident
- OAR raised for abnormal operations that has the potential to affect gas supply and customer
- OAR cultivates ownership by all stakeholders



6. OPERATION EXCELLENCE

Operations Excellence

Operations Excellence achieved through Operational Discipline - driven by Plan and Procedure Review (PPR) Program



Thank You