Operator / OEM Collaboration on Trip & Alarm Rationalization

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Author bios

Niran Singh Khaira BEng in Mechatronics & Robotics (Monash University), joined ExxonMobil in 2007. Worked multiple Machinery engineering related positions in ExxonMobil Malaysia where he first developed the Machinery trip philosophy. Followed by assignments in USA and UK. He is currently leading the Machinery Group in ExxonMobil Malaysia.

Michael Matheidas BSc - over 20 years of experience working in Upstream machinery system design, start-up, operations and research. Current role is a Regional Facilities Advisor responsible for technical and business development support to upstream production units, projects and business partners in the Asia Pacific, Middle East and Caspian regions for ExxonMobil.

Azeem Meruani - MSc – Senior Technical Advisor for Machinery Controls for ExxonMobil Upstream Production based in Houston, USA. Responsibilities include providing engineering support for ExxonMobil upstream projects and producing assets globally - key focus machinery controls. Joined ExxonMobil in 2007 as a machinery engineer.
Author bios

Mohamad-Ali Mortada, PhD – GT Controls Team Lead within the Aero-derivative Gas Turbines Department of the Distributed Power Generation Division at Siemens in Montreal, Canada. Responsibilities include delivering design improvements to the control system for the purpose of enhancing Reliability and Mean Time between Forced Outage. Joined Siemens (previously Rolls-Royce Energy) in 2011 as a Field Support Engineer working on Root Cause Investigations to resolve failures impacting product safety and reliability. Holds a PhD in Industrial Engineering from École Polytechnique de Montreal.

David Wilson is the Senior Engineering Sales Support Manager for the Siemens SGT-A35, SGT-A45, and SGT-A65 gas turbines for use in Mechanical Drive and Power Generation applications within the energy sector. He has responsibility for customer facing aspects of the Siemens Aeroderivative product lines and technical aspects in customer qualifications and customer project management. He has worked for Rolls-Royce for 27 years in various roles including helicopter, marine and energy gas turbines. He is based in Montréal, Canada.
Abstract

Turbomachinery has increased in complexity and monitoring capabilities over the last several decades. This has resulted in an increased number of trips to protect various machinery systems. The prevailing OEM philosophy has been to protect the machine assuming that an immediate trip is safer and results in the lowest financial consequences. ExxonMobil and Siemens collaborated to redesign machinery protection and control systems with an “Operator’s mindset” – considering the integrated, full plant risk. The goal was to maximize safety and minimize integrated risk resulting in an increase in mean time between forced outage (MTBFO).
Business Case

Trips can increase safety exposure by putting demands on safety systems and personnel exposure during restarts.

Downtime is often a key contributor to life cycle cost.

*Data based on LNG service, 2015 average LNG price and internal cost / downtime estimates.
Gas turbine instrumentation, protective & control systems are the largest contributors to trips.
Shift in Mindset

Solution: Changed strategy to collaborate with OEMs to update OEM standard design - Sustainable solution rather than a one off design

- More trips do not necessarily improve safety.
- More trips do not necessarily lower financial risk.
- Design one build many.
- Control systems are getting more complex, yet it is harder to determine health of machine.

- According to the U.S. Chemical Safety Board, incidents during plant start-up are 10 times more likely than during normal operations.*

Drive to Collaborate

BEFORE

“Machine only Mindset”
Alarms & Trips geared primarily towards machine Protection.

AFTER

New Risk Based Alarm & Trip Rationalization Methodology
factoring in Operator Down Time

“Operator Mindset”
Alarms & Trips to protect the facility – maximizing safety & minimizing integrated risk.

LEGEND:
ECS Engine Control System
PCS Package Control System
SIS Safety Instrumented System
ALM Alarm
CSD Controlled Shut Down
ESD Emergency Shutdown
# Methodology

<table>
<thead>
<tr>
<th>1. Develop Methodology</th>
<th>2. System Based Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Risk Based Approach Focused on Understanding Protection Rationale</td>
<td>• Maximizing Uptime using System’s Physical/Synthesized Redundancy</td>
</tr>
<tr>
<td>• Compares Risks with and Without Automatic Action to Tolerable Level</td>
<td>• Empower Operator to Manage Risks of running in Degraded State</td>
</tr>
</tbody>
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<tbody>
<tr>
<td>• Calibrate Risk Assessment Against Operator’s assessment</td>
<td>• Coding &amp; Validation of New Protections using Simulation Tools</td>
</tr>
<tr>
<td>• Alarm Management Tools (Response Procedure, Priorities, etc..)</td>
<td>• Roll-Out to Select Sites, Collection of Operational Data, and Feedback</td>
</tr>
</tbody>
</table>
OEM Process – Internal Q&A

Trip Rationale
• Do we need to trip? What is the failure we are trying to prevent trip?
• When do we arm/disarm trip?
• Is there an automatic action that can be done to prevent tripping? - Run back or trip to idle
• Is there another trip that prevents the same failure mode? Is it redundant?
• Cross reference signals to eliminate/minimize spurious instrument failure trips?
• Eliminate/minimize Single Point of Failure (SPOF) trip devices

Trip Timers
• How long is it acceptable to continue operation before tripping?
• Are there time delays/filters to eliminate/minimize instrument/processor “spikes” – example 3
### Example 1

<table>
<thead>
<tr>
<th>Abnormal Condition</th>
<th>Failure Risk</th>
<th>Trip Risk</th>
<th>Mitigation</th>
<th>New Trip Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>GT Lube Oil Supply Temperature Signal Fault</td>
<td>High</td>
<td>High</td>
<td>Use Tank Temperature for Redundancy if Sensor Fails</td>
<td>Low</td>
</tr>
</tbody>
</table>

#### Diagram:
- **Oil Reservoir**
  - Lube Oil Supply
  - Level
- **Strainer**
  - Oil Cooler
  - T
- **Pump**
- **Scavenge**
  - Oil
- **Engine**
  - Filter
  - T
### Example 2

<table>
<thead>
<tr>
<th>Abnormal Condition</th>
<th>Failure Risk</th>
<th>Trip Risk</th>
<th>Mitigation</th>
<th>New Trip Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP Compressor Inlet Pressure Cross-Check Error</td>
<td>Low</td>
<td>Low</td>
<td>Remove Shutdown and Use Synthesized Value</td>
<td>Low</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fault</th>
<th>LP Inlet P (Before) =</th>
<th>LP Inlet P (After) =</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Signal Faults</td>
<td>AVG(Sig1,Sig2)</td>
<td>AVG(Sig1,Sig2)</td>
</tr>
<tr>
<td>Single Signal Fault</td>
<td>Remaining Healthy Sig</td>
<td>Remaining Healthy Sig</td>
</tr>
<tr>
<td>Cross-Check Error</td>
<td>Shutdown</td>
<td>Use Synthesized Site Ambient P to Arbitrate</td>
</tr>
<tr>
<td>2oo2 Signal Faults</td>
<td>Shutdown</td>
<td>Synthesized from Site Ambient P</td>
</tr>
</tbody>
</table>
**Example 3**

Improved Signal Validation on All Instrumentation (e.g. IP Compressor Inlet Pressure)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal Fault Trigger</td>
<td>Instantaneous Signal Kick Out</td>
<td>Confirmation Delay of X secs Freeze Last Good Value in Mean Time</td>
</tr>
<tr>
<td>Signal Reinstall</td>
<td>Can Only Reinstall After Engine Shutdown</td>
<td>Automatic Signal Reinstall if: 1- Signal Returns to Normal X sec/mins within Fault 2- Signal Experiences “Y” mins of Good Behavior during the reinstall window</td>
</tr>
</tbody>
</table>
Results

- Exercise Conducted on SGT-A65 Gas Turbine Control System
- New Software Tested & Implemented at Several Sites
- Solution is Now the New Standard for Siemens
Conclusions

• Operators and OEM collaboration resulted in a new standard solution for the OEM.
  • 20-25% expected increase in run time between forced outages
  • Prioritized alarm list following industry standard – ISA 18.2
  • Benefits customers for new units
  • Scope expanding from SGT-A65 TR to other unit types
  • Software changes can be incorporated into existing equipment
  • Sustainable solution - OEMs continue to learn and improve with fleet data by addressing repetitive trips
• Benefits the industry if more operators collaborate with OEMs to improve OEM standard design.