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Research Article

Retrofit of Fire & Gas Detection System at Offshore Oil & Gas Installation: Case Study under the framework of Safety Life Cycle of ANSI/ISA-S84.01.

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Abstract

This paper discusses the case study of retrofit of Fire & Gas system for a process gas compressor at an offshore oil & gas installation in Mumbai High-India. Fire & Gas detection system is a key component in the overall safety and operation of offshore process gas compressors. Worldwide, efforts are going on to bring F&G detection and mitigation systems under the broad framework of functional safety systems which follows the concept of safety life cycle of the system. Safety life cycle begins with the conceptual design and ends with de-commissioning of the system. Backed by seventeen years of offshore working experience of author, present paper critically analyses the retrofit job in context of safety life cycle as mentioned in functional safety standard of ANSI/ISA S84.1.

Keywords: *Fire & Gas Detection System, Process Gas compressor, Programmable Logic Solver, Safety Life Cycle, Functional safety Standard*

1. Introduction

Fire & Gas (F&G) Detection and Mitigation System is an essential protection layer in risk management of any offshore process gas compressor. The F&G system of one of the process gas compressors (Rolls Royce-Man GHH) failed due to "Configuration Error" fault. M/s Terra Fire which is the OEM of the system was contacted for assistance as further trouble-shooting was not possible in the absence of necessary software interface to access the application program. M/s Terra communicated their inability to solve the problem as the existing system was obsolete and spares were no longer available. OEM advised to go for the total revamp of the system and quoted with an exorbitant price of 381,600.00 USD plus 2,500 USD per day for service engineer and that too with a long lead time.

Considering the criticality of situation, a brainstorming session was initiated at platform to find out the best possible solution after deliberating the requirements of new performance based functional safety along with recommended practices mentioned in API RP 14C (*American Petroleum Institute : Analysis, Design, Installation and Testing of Basic Surface Safety Systems on Offshore Production Platforms*), API RP14G (*American Petroleum Institute: Recommended Practice for Fire Prevention and Control on Open Type Offshore Production Platforms*) and API 14J (*American Petroleum Institute: Recommended Practice for Design and Hazard Analysis for Offshore Production Facilities*). It came out that the field wiring and field sensors were in working condition but system was unable to execute the application program and subsequently generate the interface signals to suppression system due to faulty logic solver. Earliest feasible solution with minimum financial implication was to replace the faulty logic solver with a spare PLC which was available at platform. Idea was to interface this spare 90-70 PLC of GE make with existing field sensors, UCP and platform F&G system with the help of some additional hardware. Platform engineers took-up the challenge of development of conceptual design followed by detailed design and engineering along with broad spectrum of application program. Onshore technical support team took it to a logical conclusion by vetting the design and engaging an external agency with relevant experience to execute out the job. As a stop gap arrangement wiring of thermal detectors, HC Gas detectors and UV detectors of GG enclosure for coincident trip (2 out of N voting logic) was modified and rerouted to UCP. This arrangement ensured the tripping of the compressor in case of HC gas detection, thermal detection and coincident UV detection, till the retrofit job is completed. Line monitoring for field output loops was introduced to increase the reliability as per the guidelines of functional safety standards of IEC-61511 and ISA-S84. Platform engineers finalized the layout for cable laying, relay installation, power distribution and shifted the existing field and interface wiring to a better alternate location. Platform engineers provided valuable contribution in development of final application program and HMI schematics. System was

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commissioned successfully after carrying out cold and hot loop checks and functional check of complete F&G logic.

2. Execution of Retrofit Job

Job was co-ordinated and executed with perfection by installing new hardware of line monitoring, Genius Bus Controller and BBD modules in spare GE Fanuc PLC. Following were the detailed activities to execute the job:-

- The spare GE Fanuc LM90-70 System Rack was checked for integrity. The system rack was removed with CPU771, Power supply, two numbers of digital Input cards and a digital output card.
- Installed LM 90-70 system at place in Terra fire control system of PGC.
- Installed new hardware of line monitoring, Genius Bus controller and BBD module.
- Dismantled the old F&G control system.
- Removed the old display unit and installed the new 6" HMI of GE Fanuc.
- Finalized the layout for cable lying, relay installation, power distribution, installation of MCB.
- All the Input output field wirings, interconnection wiring with UCP and NQP main F&G were shifted from OLD F&G system to New GE LM 90-70 Input- output modules as per the prepared layout.
- Carried out the cold loop checks for all the inputs from GAS Rack, H2s rack and UV controller.
- Developed the application program with F&G logic and graphics for HMI.
- Powered up the PLC and loaded the logic and hardware configuration.
- Powered up the HMI and downloaded the software.
- Established communication between PLC and HMI, PLC and engineering station, HMI and engineering station.
- Configured Genius Block for line monitoring.
- Carried out The hot loop checks for all the configured input output tags of the PLC.
- Carried out the testing of logic by simulating inputs from field. Verified the outputs on HMI and PLC output modules and necessary corrections were carried out in logic.
- Checked HMI Graphics for alarms and appropriate display of the I/O status.
- Carried out the functional check for FM200 system by simulating UV and thermal sensors from field and observed the solenoid outputs from Genius Block for actuation of FM-200.
- Carried out functional checks for interconnection wiring from F&G system to UCP for Compressor shutdown and annunciation.
- Control system commissioned and taken online.
- Prepared the as built wiring drawings and backup of PLC Logic, HMI and BBD configuration taken on CD.

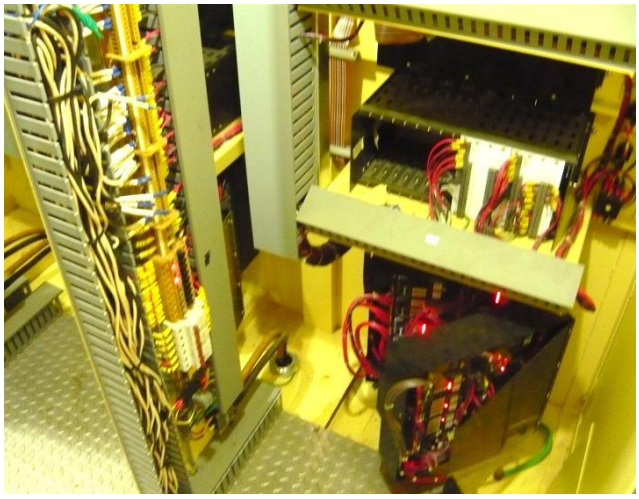

Figure 1 Old F&G System

Figure 2 Revamped F&G System

3. Critical Analysis of Retrofit of Fire & Gas Detection System

Safety Life Cycle is an engineering process that contains all the steps needed to achieve high level of functional safety during conception, design, operation and maintenance of critical systems like F&G systems. Following diagram shows the concept of safety life cycle as considered in ANSI/ISA S84.01 (*ANSI/ISA-ISA 84.01-1996, ISA, Research Triangle Park, NC (1996)*: Application of Safety Instrumented Systems for the Process Industries.)

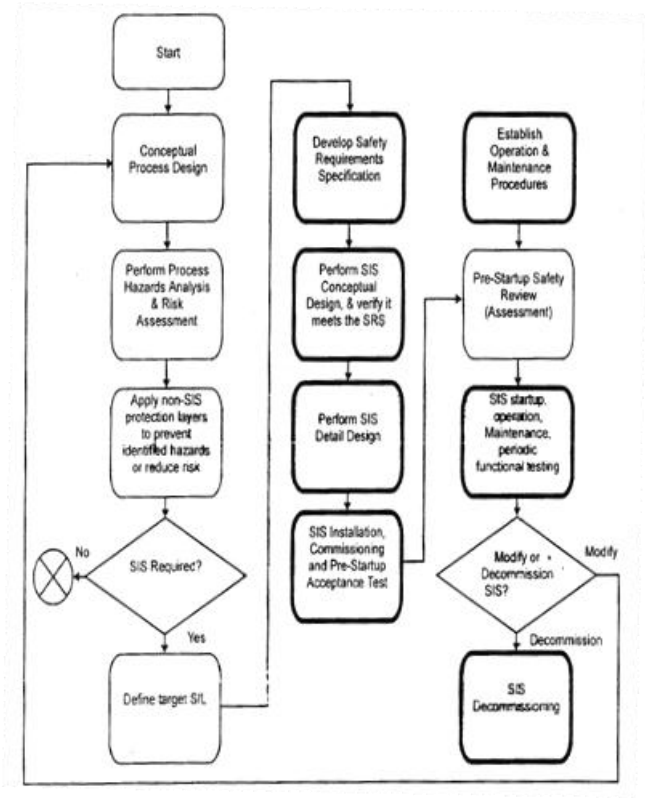

Figure 3 ANSI S 84.1 Safety Life Cycle

A qualitative approach was followed for the concerned retrofit to consider different steps of safety life cycle. A multi-disciplinary team comprising of HSE Manager, Process Manager, Maintenance Manager along with instrumentation in-charge ruled out the fresh requirement of quantitative risk assessment which would have been impractical. Existing HC gas detectors, UV detectors, Thermal detectors along with final SOVs were functional and were found to be in very good condition. It was also suggested to introduce line monitoring for field output loops to increase reliability and to ensure the availability of system at time of demand. Following is the list of activities with in the broad guidelines of safety life cycle of ISA S84.1:

3.1 Management of Change (MOC)

MOC document was initiated citing the reasons for proposed decommissioning and subsequent installation of new F&G system. An approval was taken after addressing the following issues:

- The technical basis for the proposed retrofit.
- Impact of change on safety, health and environment along with production loss.
- Modifications for operating procedures.
- Necessary time period for the change.

3.2 Conceptual Design

Initial conceptual design was proposed considering applicable codes and standards for offshore regulation, environmental and hazardous area classifications. Programmable Logic Controller (PLC) was selected as a logic solver.

HC gas detectors, Thermal detectors, UV detectors and solenoid valves (SOV) will be retained. F&G system will be designed such that once actuated, it shall remain in safe state until a reset has been initiated. Safety requirements specifications shall address the requirement for manual or automatic reset Manual means, independent of the logic solver shall be provided to actuate the final SOVs unless otherwise specified by the safety requirement specifications.

3.3 Detailed Design

GE Fanuc LM90-70 System was selected as a logic solver which was already in use at same installation in master F&G system. Redundant power supplies were used but rest of the architecture was on 1oo1 architecture. Due to introduction of line monitoring facility, energize to trip design was selected. Some of the other features of detailed design are as follows:

3.3.1 Operator Interface Requirements

Operator interface system has been designed such as that upon failure of operator interface, automatic functions shall not be compromised. Also, sufficient means have been provided for the operator to detect any F&G hazard and released suppressant, if any.

Communications signals are isolated from other energy sources through the use of good engineering practices e.g. use of shielded cable while maintaining a single ground plane with a single dedicated power.

System has been designed that changes to the F&G application software shall not be allowed from the F&G operator interface.

Separate F&G maintenance/engineering interface with dedicated development software has been provided. Following functions are part of engineering interface:

- Access security protection to F&G operating mode, program, data, means of disabling alarm, communication, test, bypass or maintenance.
- Access to diagnostic, voting and fault handling services.
- Access to add, delete or modify application software.

3.3.2 Maintenance or Testing Design Requirements

System has been designed such as the operator shall be alerted to the bypass of any portion of F&G system via an alarm.

Bypass of any portion of the F&G system shall not result in the loss of detection and annunciation of the condition being monitored.

Forcing of inputs and outputs shall not be used as apart of application software, operating procedures and maintenance.

Forcing of inputs and outputs without taking the F&G system shall not be allowed unless supplemented by

procedures and access security. Any such forcing shall be enunciated and alarmed.

3.4 Installation, Commissioning and Pre-Startup Acceptance Test (PSAT)

A dedicated team of technicians, supervisors led by an instrumentation engineer was formed to carry out installation and commissioning activities to ensure that system is installed as per the detailed design documents and is performing as specified in the safety requirement specifications. It also ensured that

- Sensors and logic solver are properly installed and wiring is properly done.
- All sensors have been properly calibrated
- Field devices and logic solver are operational.

Documentation to substantiate completion of the commissioning and PSAT were completed prior to the introduction to F&G system in line. During installation, commissioning or PSAT, any modification or change to detailed design were noted, reviewed and vetted.

3.5 Operation and Maintenance

A maintenance program has been established, which includes written procedures for maintaining, testing and repairing of system

3.6 Functional Testing

To detect covert faults, periodic testing of complete system including sensors, the logic solver and final elements shall be carried out (*International Electro technical Commission, Ganeva (2003): IEC 61511: Functional Safety – safety instrumented systems for the process industry*). A documented functional test procedure, describing each step to be performed, has been prepared.

Functional check shall be carried out at specific intervals based on the frequency specified in safety requirement specifications. Different portions of system have different periodic test intervals.

After every 3 years, the frequency of testing shall be re-evaluated based on gained experience, historic data, hardware degradation or software reliability.

Any change to the application logic requires full functional testing.

3.7 Documentation of Functional Testing

A description of all tests performed has been documented. The user shall maintain records to certify that tests and inspections have been performed. Documentation shall include date of inspection, name of person who performed the test or inspection, tag of sensor, results of inspection/test ("as-found" and "as-left" condition)

4. Conclusion

An appropriate framework to systematically assess, control and manage the overall process safety requirements of offshore process gas compressor was created by following the steps of safety life cycle of international standard of functional safety ISA S84.1. A multidisciplinary team with expertise in process, instrumentation, control, safety, maintenance and reliability was used to develop the basis for the design, implementation and maintenance of a F&G system which is capable of achieving stringent safety requirements of high risk offshore process gas compressors. Reliability and safety integrity of revamped F&G system has been enhanced by introducing the line monitoring facility in field output loops. Job was executed with 12 % of cost against a 381,600.00 USD quote from OEM and was finished much faster against the anticipated high lead time of OEM. This has not only resulted in increased safety but also helped the company to be more productive and effective in its operational and maintenance practices.

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