

# **Programmable Safety Systems for Burner Management on Gas Turbines.**

As the demand for energy throughout Australia increases the demand for alternative sources is increasing accordingly. The use of gas turbine generation to supply small to medium requirements is becoming increasingly popular.

The principles of Safe Burner Management in typical gas Boiler/Burner applications are equally relevant to Gas Turbines. Many existing Turbines in Australia were installed prior to current standards and regulations and in many cases using traditional Hard Wired control systems. As these control systems are being upgraded with current technologies such as PLC's and DCS's special attention must be paid to ensure regulations are complied with.

A practical example of what is required occurred when a new gas generation plant was installed recently in the Latrobe Valley. 20 year old Gas turbines were brought over from New Zealand with an upgraded control system being designed and installed by an overseas based company. Although the upgrade was using a modern high quality PLC based control system it was realised that this system was not approved for use in Australian Gas applications under the codes AS3814-2002/AG501.

It was decided that an approved supervisory PLC system would be installed in conjunction with the non approved control system. The following paper discusses how the system was implemented and the required compliance was achieved.

## **Principles of Gas Turbine Operation:**

As with conventional burners, gas turbines must follow the same gas safety techniques required by AS3814-2002/AG501. This safety process includes Purging, Valve position proving, ensuring correct ignition (Light Off) and continuous flame monitoring. Whilst some of these processes are the same in Gas Turbines as Boilers, the way in which they are achieved can be different.

The turbine start commences when a compressed air starter is used to spin the turbine up to a set speed of 1500RPM. Once this speed is reached a 30 second purge begins. The 1500 RPM set point must be proven to be maintained for the full 30 second period to ensure the correct volume of air has purged the system. At the end of the purge cycle the valves are opened and a spark ignites the gas. Compressed air is removed and the exhaust from the burning gas now drives the turbine. Ignition must now be proved; conventional techniques such as flame detectors are not viable on a turbine so another speed set point is used. The turbine must now reach a new higher speed level (2300 RPM) within a set time of 15 seconds. This set point proves that the gas has ignited as the 2300 RPM is well over the maximum speed attainable by the air starter, this ignition is termed "Light Off".

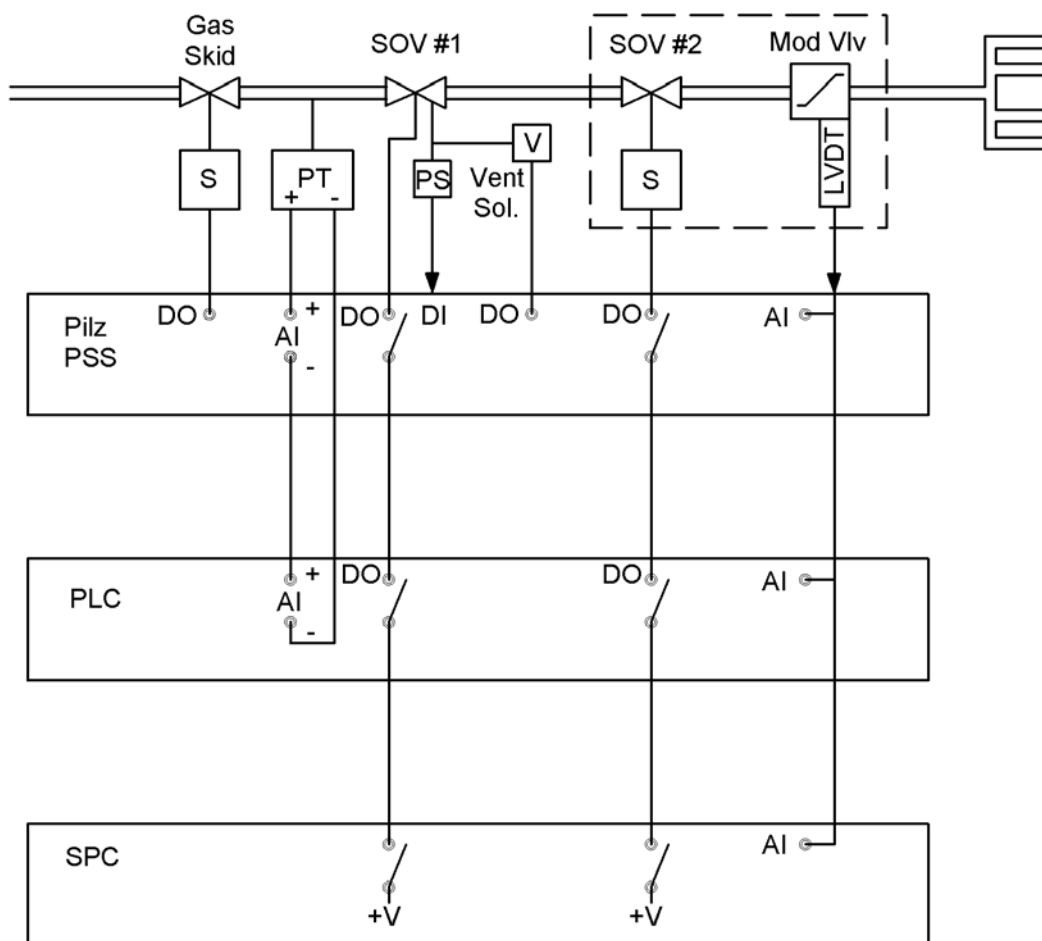
The Turbine is now run up to its operational speed with a modulating gas valve being controlled by the standard PLC control system. The Safety system is now monitoring for loss of flame known as Flame Out and other continuous conditions which will be described in the following sections.

In the described application two turbines (A and B) are connected at each end of the Generator in what is called a “Twin Pack” arrangement. Air Coupling from the Turbine to the Generator allows the turbines to operate singly at half power or together. Each turbine is capable of producing 25MW, therefore a 50MW capacity is available from each Generator set.

## Safety System Description:

A Pilz Programmable Safety System (PSS) was chosen as the supervisory safety PLC as it provided the technical requirements, was cost effective and is approved for use by TUV as specified by AS3814-2002/AG501. A 5 Slot PSS 3100 rack was used on each of the 6 turbines. Each PSS3100 was configured with 48 Digital Inputs, 16 Digital Outputs, 12 Relay Outputs, 6 x 4-20 mA analogue inputs and 6 x -10 to +10V analogue inputs.

Fig.1 Gas Valve Layout



## Safety System Operational Requirements and Implementation:

Figure 1 shows the layout of the valve system which is duplicated for each turbine on a Twin Pack. The Main Shut off Valve is located on the Gas Skid and provides a primary isolation point for the turbine, it is closed if an Emergency stop condition results and when the Turbine is not in operation. The Shut Off Valves (SOV) SOV1 and SOV2 provide a redundant means of isolating fuel from the Turbine and provide primary protection. The Modulating Valve (MOD) controls fuel flow to the Turbine for speed control.

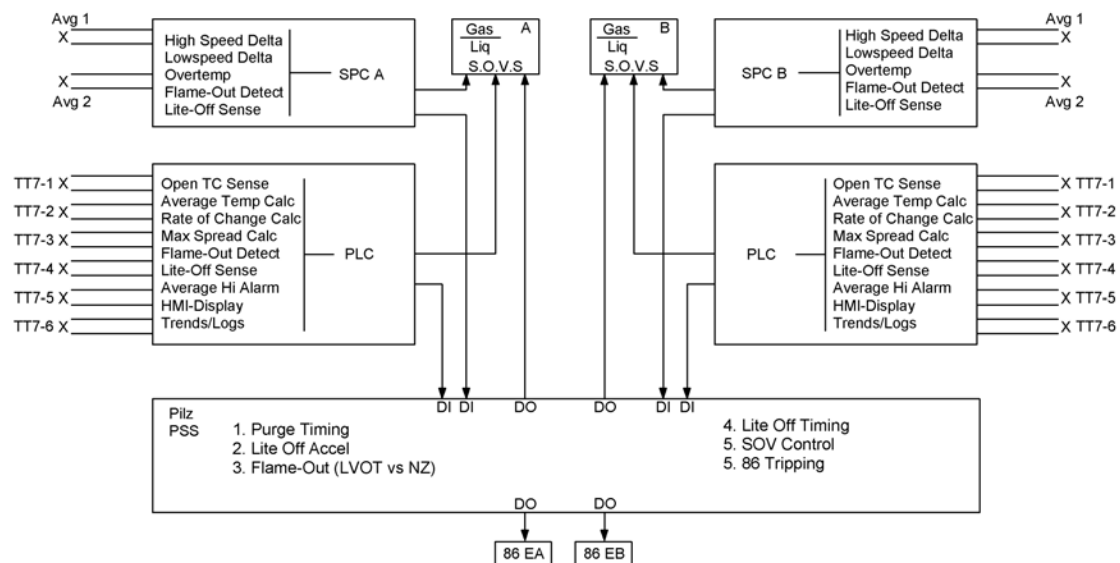
The PSS has the final shutdown control of the system. The PLC is the primary control system and works in conjunction with a secondary control system called SPC.

The following points describe the PSS operation for the complete turbine cycle. Depending on the condition either a single Turbine may be shut down, which is called an 86Ex trip where x is the A or B unit. Other conditions require the complete Twin Pack to be shut down in an emergency stop type condition which is called an 86 GX/Y trip.

### 1. Valve Leak Test.

At commencement and finish of each run a valve leak test is performed. Two Pressure switches (PS) are installed between SOV1 and SOV2. At start up the Main SOV is opened whilst SOV1 remains closed. A low pressure switch between SOV1 and SOV2 checks for SOV1 Leakage for a 15 second period. SOV 1 is now opened to pressurise the chamber between it and SOV2. SOV1 then closes and the chamber is then proven to maintain pressure for 15 seconds by a high set pressure switch. This tests the integrity of SOV2. During the test the LVDT of the MOD Valve is monitored continuously as a further test of the integrity of SOV2. A failure of the leak test shuts down a single turbine with an 86Ex Trip.

Fig 2. Temperature Protection.



Temperature protection (Fig. 2) consists of a number of start up and continuous tests throughout the turbines operation. Primary protection is provided by two sets of thermocouples mounted in the exhaust case of the turbine. The thermocouples are monitored by the SPC and PLC. The critical stages of the process that can cause over temperature, being the correct burning process are monitored by the PSS in conjunction with the other control systems.

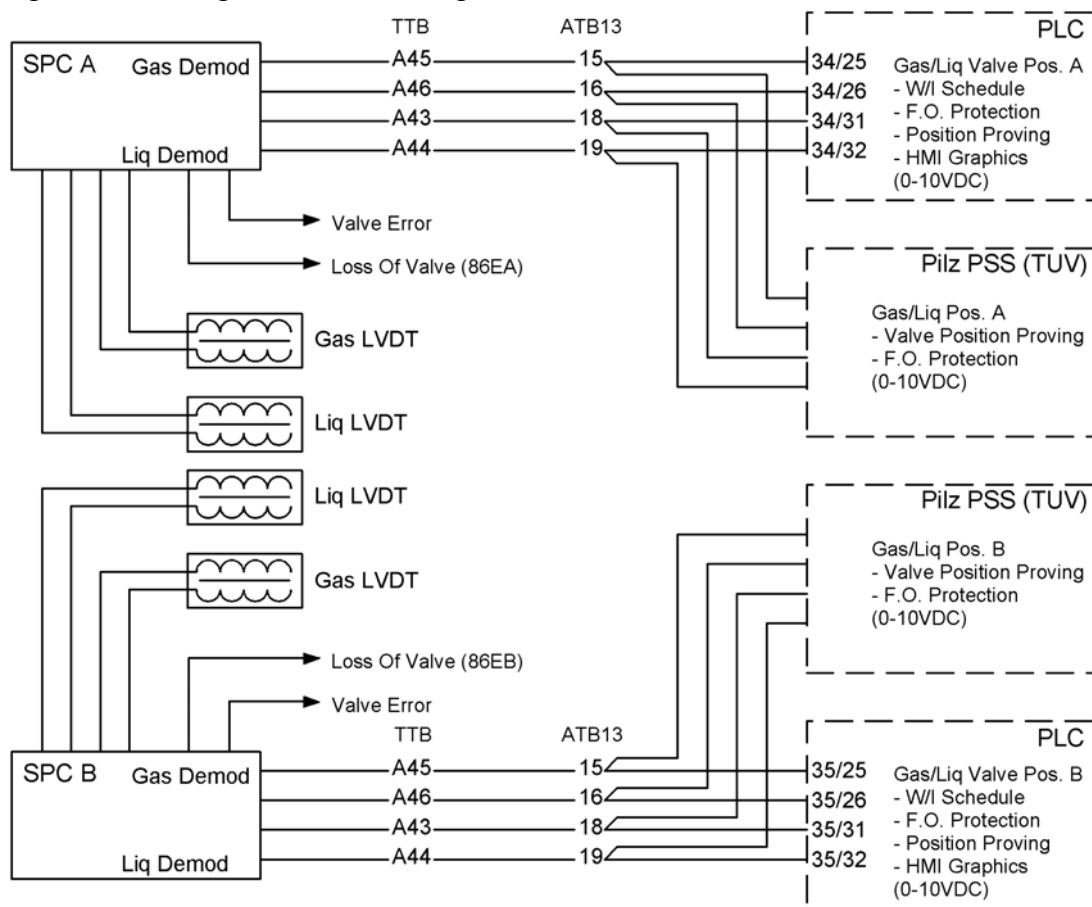
### 1. Purge

Once the valve leak test has completed successfully a Purge Step commences. A minimum turbine speed of 1500 RPM must be maintained for 30 seconds to evacuate any unburnt fuel from previous runs.

### 2. Light Off

After the Purge, SOV 1 and 2 open and the modulating valve allows gas to flow. A spark ignites the gas. A successful Light Off has occurred if the Turbine speed is driven up by the exhaust gases to a set speed of 2300 RPM in 10 seconds. The PLC and SPC also detect light off by comparing temperature rise over time providing three independent and diverse proofs.

Fig 3. Modulating Valve Monitoring.



### 3. Flame Out

Once Light Off is proven a number of continuous monitoring conditions take place for the duration of the Turbine's operation. The first of these is monitoring for Flame Out. The PSS monitors for this by comparing the rate of change of the MOD Valves position over time. In a Flame Out condition the MOD valve will open far more quickly and over a larger angle than during normal running as it tries to maintain Turbine speed.

### 4. Gas Pressure and Flow.

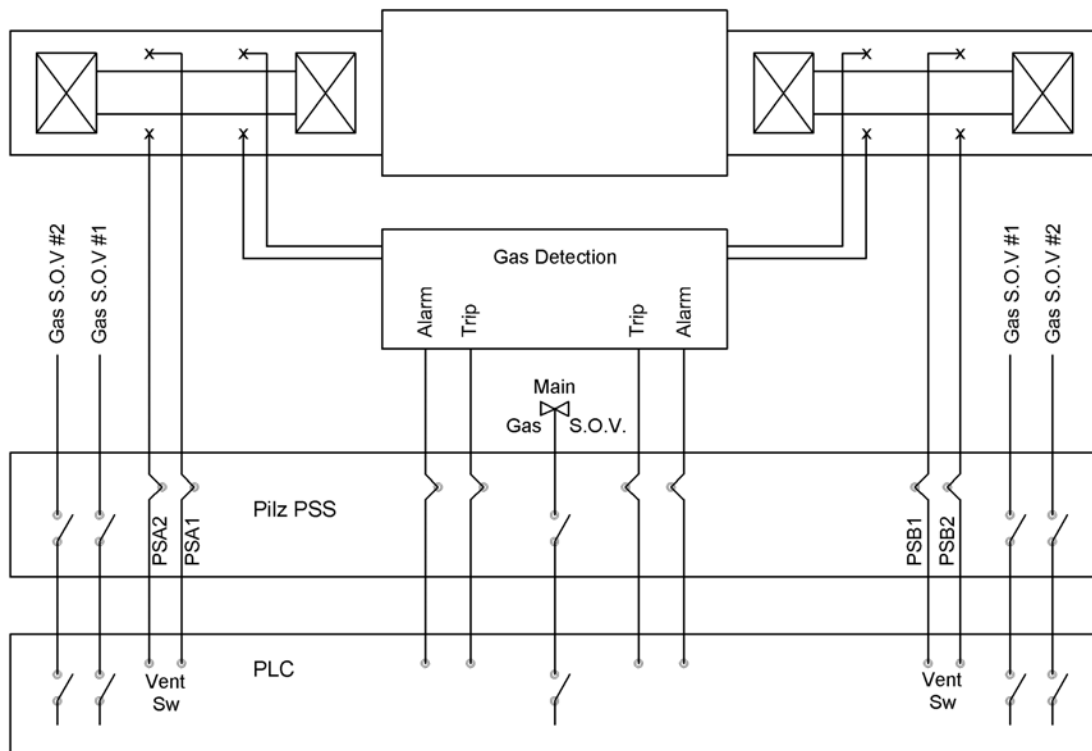
A Flow Transducer is used to monitor the Gas Flow continuously. If the flow exceeds a certain limit an 86 GX/Y trip occurs. This is to detect gas escaping due to catastrophic failure or rupture of the line.

A Gas Pressure Transducer monitors for over pressure which can result in a poor air to fuel mix. An 86Ex trip occurs in such a situation.

### 5. Gas Leak Detectors.

Gas leak detectors are installed in the Turbine enclosures to detect any gas build up. An 86 GX/Y trip occurs if gas is detected.

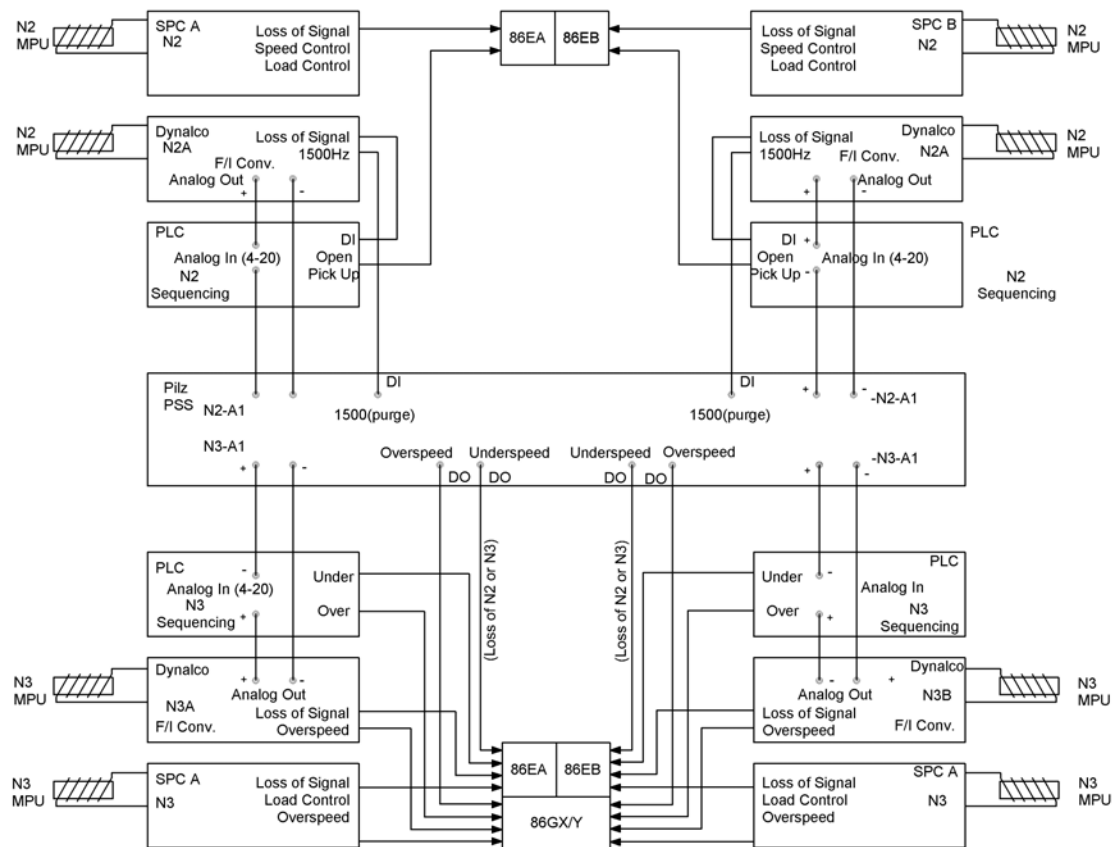
Fig. 4 Air Flow and Gas Detection.



## 6. Secondary Air Switches.

As a protective measure in case of gas leakage the Turbine enclosures are ventilated. The air flow from the enclosure is monitored by a pair of position switches attached to exhaust flaps which are wired to the PSS and the PLC. These switches are proven to operate correctly at each fan start stop.

Fig 5. Speed Monitoring.



## 7. Turbine & Generator Speed Monitoring.

The Turbine speed (N2) and Generator speed (N3) are monitored redundantly with analogue signals being transduced by a DYNALCO transducer and SPC speed controller. The DYNALCO's signal is fed into the PSS and the PLC. An over speed condition shuts both Turbines down with an 86GX/Y trip.

## **Conclusion:**

Just as Standard PLC's have become common place in Industry over the last twenty years, Programmable Safety Systems or Safety PLC's are now becoming standard equipment in Australia as end users and system designers are become aware of the engineering and cost advantages.

By using a Programmable Safety System, the 20 year old Turbine Generators were able to be brought up to current safety specifications with the benefits of modern PLC technology. Diagnostic information was communicated to the plant SCADA via a Modbus link which enables operators to view safety system status from the control room located remotely.

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