Application Note

Gas Turbines

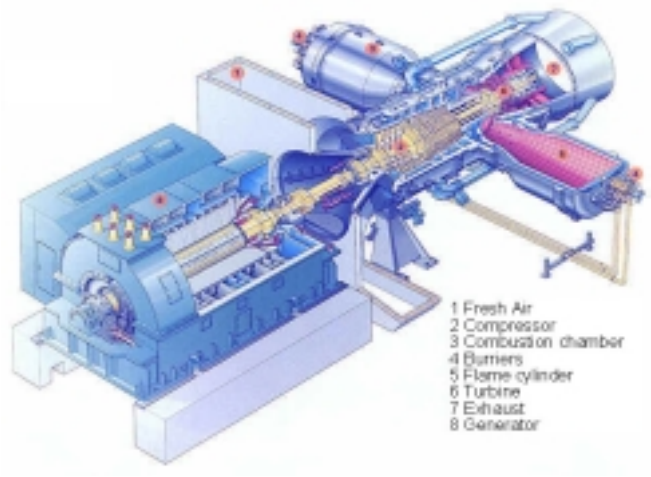
Introduction

Beside aircraft types there is a wide range of industrial applications for gas turbine devices. They are used to drive rotating equipment such as compressors at gas pipelines or electrical generators for energy production. Continuous output ratings of more than 30 Megawatts per unit are possible.

Modern gas turbines are designed to burn light oils (Naphtha) or natural gas. But not only the fuels also the lubricating oils and cooling agents like hydrogen add-up to a high degree of hazard potential. For this reasons a multiple line of defence has to be established to guaranty protection against fire and explosion risks. Gas detection instruments are the central element in the protection systems.

Market Segments

The total market of gas turbines is about 1000 units a year, representing up to 8000-10000 gas detection points.



The main producers of turbines are:

- General Electric (market leader)
- Siemens/Westinghouse
- Alstom
- Caterpillar/Solar Turbines
- Mitsubishi

Typical applications:

- Compressor Stations at Gas Pipelines
- Oil Production
- Power Generation
- Water & Sewage Pumping Stations
- Oil & Gas Wellhead Re-injection

Description of the Challange

There are three main areas of risk assessment related to gas detection systems. All different segments require specially matched systems with features optimised for each application.

1. Turbine Air Intake

Gas turbines are typically located in areas where large amounts of combustible gases or liquids are stored. They are either used as fuels to feed the turbine or they are part of the application itself as in gas pipeline compressor stations. Leaks in this area can have disastrous consequences when the supply air of the turbines is already loaded with combustible gases or vapours. There is a genuine risk of pre-ignition of the air/ gas mixture in the compressor stage of the turbine or the excess of fuel can result in an uncontrolled over-speed of the turbine. Both situations require immediate shut down of the turbine.

To generate an early warning the intake air has to be controlled for any build-up of hazardous combustible gas concentrations. Infrared optical measurement techniques have proven to be reliable and fast detection systems for these applications. The best place of positioning of the detector is just outside or in the air intake hoods. Positioning is critical with regard to the high air speed in the ducts. Special care has to be taken to avoid miss readings of gas concentrations related to these modes of operation.

2. Acoustic Turbine Enclosure

The significant noise levels of gas turbines often require an acoustic enclosure. They have to be ventilated to ensure an optimum temperature range of the turbine. Typical operating conditions are 40 - 60 °C. However, under hot environments, near the combustion chamber or under equipment failure conditions the internal temperatures can reach values up to 100 °C.

The turbine is feed with high pressure (700 p.s.i./ 50 bar) combustion fuel. Hundres of connections and the complex distribution system are always a source of potential leakage inside the enclosure. Also the lubrication oil system can spill into the acoustic chamber in case of malfunctions. To prevent the system under these circumstances from a build-up of high concentrations of flammable gases a gas detection system has to be installed.

Most detectors are restricted to upper limits of 65°C as for example optical measurement systems. These set-ups require positioning of the detectors outside the enclosure and extractive sampling systems with additional measurement gas conditioning.

Also open path measurement systems are located outside the acoustic chamber but overlooking the inner part of the chamber through IR transparent windows or special duct mountings. They are known to guaranty fast response and increased coverage of explosion hazards.

As an alternative high temperature resistive catalytic bead detectors with operational temperatures up to 120°C can be used. They can be located directly in the enclosure near the turbine avoiding special extractive sampling systems.

3. Hydrogen Cooling System

Power output rating of all combustion turbines is based on the inlet air temperature. Output capacity of the turbines decreases with increase in ambient air temperature. Therefore, in hot weather climates or on hot days, cooling of turbine inlet air has been found to be cost effective for many power plants for boosting power output. Hydrogen driven heat exchangers are frequently the best choice for removing

heat from the high power generators in this application. Hydrogen has a high heat capacity and, therefore, removes excess heat efficiently. Hydrogen also has a very low viscosity (or windage), thus allowing higher capacity operation of the generators while maintaining efficient cooling.

On the other hand Hydrogen is known to be a highly combustible gas. Leaks in the closed cooling system cycles can be an additional source of a potential hazard while operating a gas turbine. Catalytic bead detectors or electrochemical sensors are highly sensitive in detecting H_2 and can pick up this risk.

Solution from Dräger

Dräger offers a complete range of solutions for all safety applications around gas turbines. Catalytic and infrared sensors for combustible gases and electrochemical gas sensors for monitoring of toxic gases and hydrogen are available.

- **Infrared Point And Open Path Gas Detectors**

The installed base of more that 30.000 Polytron IR transmitters proves the experience and the unrivalled technology of Dräger infrared gas detectors. The fast speed of response of less than 5 seconds, maintenance free operation and self test functions guaranty reliable warning and a low cost of ownership of the safety equipment.

Duct mounting installations at the air intake points as well as in exhaust ducts of the acoustic chambers belong to the standard portfolio of Dräger gas detection equipment. When temperatures above 65°C restrict the direct measurement at the point of hazard with infrared instruments a complete sampling system including measurement gas conditioning can be offered.

At pipeline compressor stations a set-up of multiple turbines is common. Open path gas detection offers the possibility to overlook a possible build up of combustible gases across the hole area. A system of beams oriented in a right angle position further increases the probability of detection. Also at the air intake hoods open path detectors are a valuable addition to pure point detection systems.

- **Catalytic Bead Detectors**

Especially at the measuring points of the internal area of the acoustic chambers very high temperatures are possible. To avoid an aspirator system and the related delay of response it is also possible to use catalytic bead detectors for flammable gases specified for temperature up to 120°C. They can be placed directly at the point of hazard. Pellistors are also the only possibility to detect Hydrogen leaks in the LEL range. While IR detectors are not sensitive to Hydrogen catalytic bead sensors are known to give reliable warnings in the 0-100% LEL range.

- **Electrochemical Gas Detectors**

Even small leakages of Hydrogen can be detected by electrochemical sensors. This guaranties the earliest warning and the possibility of controlled actions of safety measures to avoid a build up of hazardous concentrations. Measurement ranges down to 0-500 ppm and even lower alarm settings are possible when using Polytron 7000 H_2 transmitters.

Another source of hazard risks can be an accumulation of toxic gases generated via leaks in the exhaust systems of the turbines. In such cases toxic Carbon Monoxide concentrations and Oxygen depletion can be measured by electrochemical sensors.

For detailed description of the technical features of all Dräger gas detection transmitters visit our homepage under www.draeger.com/gds**.**

Advantages of the Dräger Solution

Catalytic bead detectors:
- low capital cost
- high temperature versions available from October 2002
- detection of hydrogen

IR detectors:
- lower cost of ownership.
- open path offer increased coverage.
- IR detectors have the fastest response time.
- fail-safe operation due to self-test features

Restrictions

As mentioned above the temperature limit for IR detectors is 65°C. In cases where higher temperature ranges are required the use of HT- pellistor technology is strongly recommended.

References (internal, external)

Shell, Brunei
Statoil, Norway
Siemens, several locations as:
- CCPP Huntstown, Ireland
- CCPP ENEL (Priolo Gargallo, Termini Imerese, Rossano Calabro)
- CCPP Tapada do Outeiro, Portugal
- CCPP Otahuhu, New Zealand
- CCPP Bugok, Südkorea
- CCPP Phu My 3, Vietnam

Appendix

In this note only gas detection around the gas turbine itself has been considered. The purpose for which the engine is being used may also be important. For example in many pumping stations for the transmission of natural gas the compressors are driven by gas turbines. In this case more gas detection is required to cover safe operation of the compressor itself.

Relevant Norms:

USA NFPA37 / API 616 / ANSI B133
GB BGC IM24 / IP15

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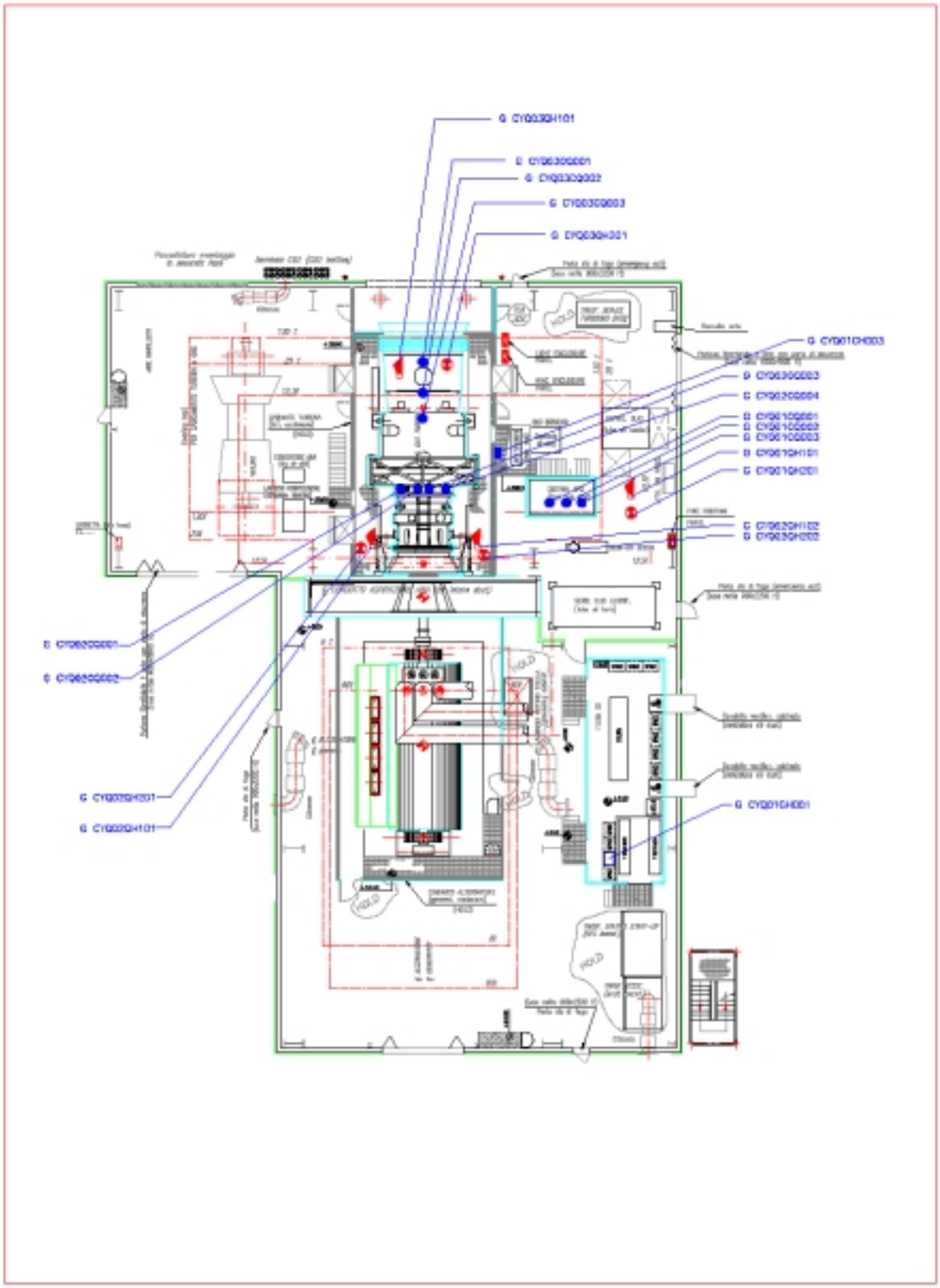
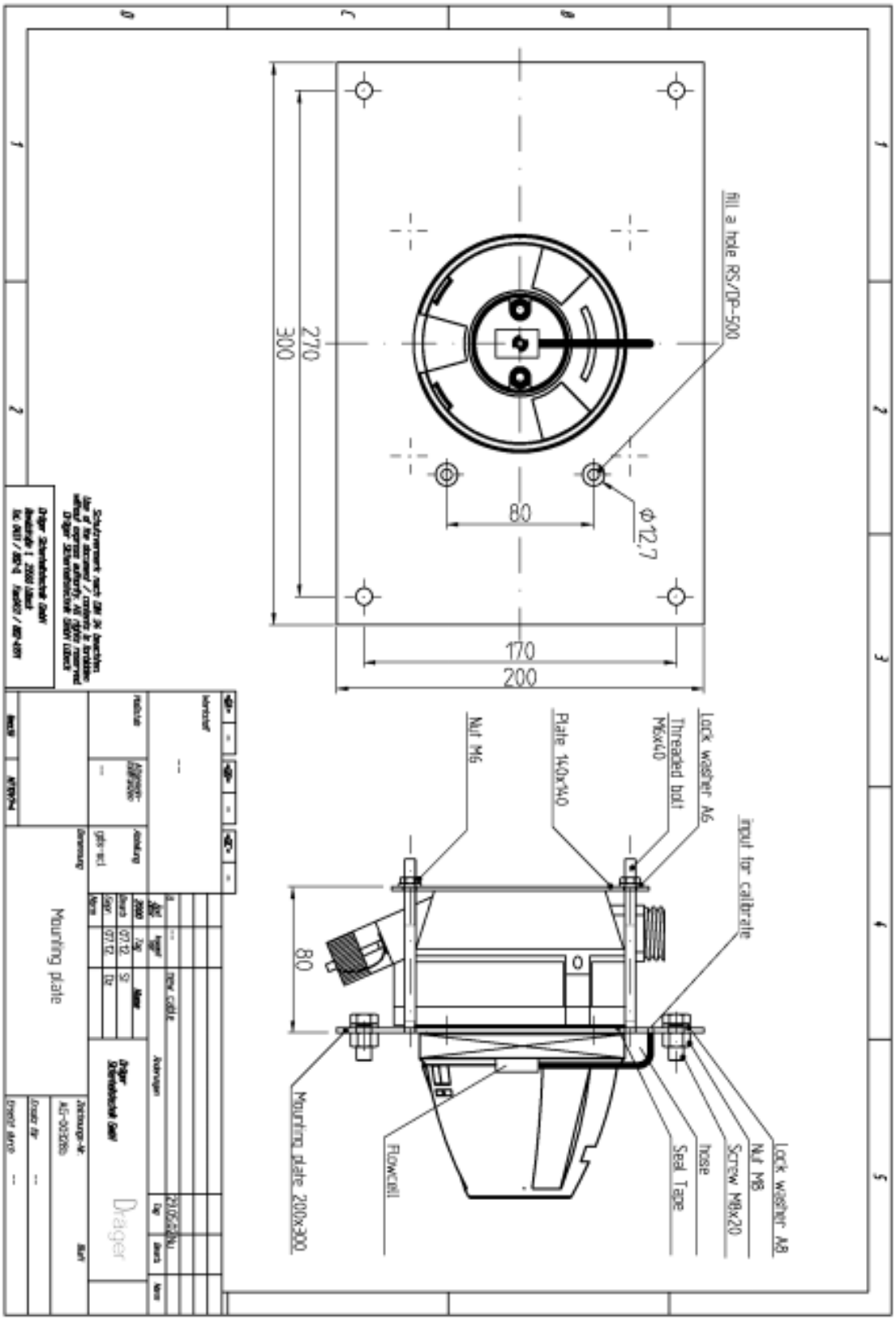


Example: Transmitter Location Gas Turbine



Drawing : Duct Mount Polytron 2 IR