Application note
Hydrogen cooled alternator purging

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The Power Plant industry and MTL alternator purge analyser range

Modern power station installations regularly use Hydrogen gas, with its excellent thermal conductivity properties, as the coolant medium for high capacity turbo generators or alternators; with the efficient performance and safe operation of the plant being critically linked to the gas quality used.

Why are alternators hydrogen cooled?
As with any electrical device, flowing electrical currents will generate heat. Large power plant alternators are essentially giant conductors with high electrical currents flowing through them, in turn generating large amounts of heat. If the heat is not effectively removed then the alternators windings can quickly degrade and become irreparably damaged. Common symptoms include insulation blistering and growth/elongation of the conductors, leading to clearance and balance issues.

When selecting the cooling gas for an alternator, several goals need to be achieved; namely:

i. Minimizing drag arising from the coolant gas ("windage") losses.
ii. Maximise alternator output by optimizing heat transfer.
iii. Ensure safe operation.

Whilst in small alternator units, air or water cooled designs have been widely utilised, as soon as the alternators approach 100MW in size then the efficiencies of these designs tends to fall away quickly. The solution to this is to use hydrogen as the coolant gas.

Hydrogen offers a number of beneficial characteristics as a coolant gas to bathe the alternator windings and removing the generated heat. These include:

i. Hydrogen has an extremely low density, yielding a very low drag coefficient.
ii. Hydrogen has the highest thermal conductivity properties of any gas.
iii. Hydrogen is relatively inexpensive, especially compared to Helium or other low density gases.
iv. Hydrogen is relatively easy to manage as it is not readily miscible with purge gases such as CO2.

These factors combine to make Hydrogen the near ideal coolant, except for its one major flaw in that it is explosive when mixed with air and exposed to an ignition source. However, if the purity of the hydrogen gas can be maintained at a very high level (above its UEL Upper Explosive Limit of >75% H2 in Air), then, even if there was an ignition source, there could not be an explosion.

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How does it work?

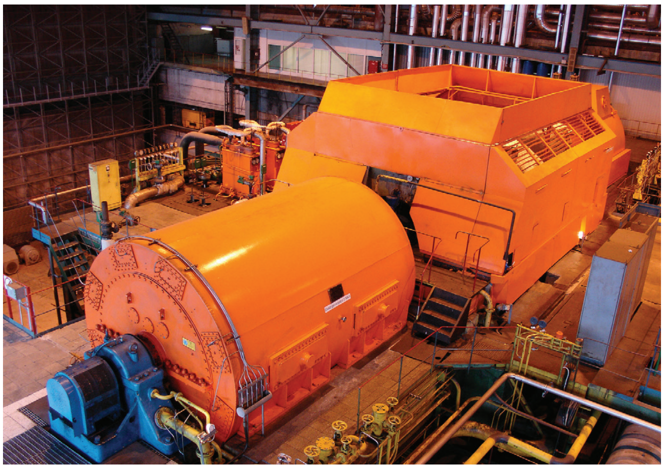
Cool hydrogen gas is recirculated by fans located at either end of the alternator rotor, cooling the alternator windings and rotor as it flows. It is then directed over a series of water cooling coils, where the heat which has been absorbed by the hydrogen gas is removed. Finally being recirculated back through the alternator and rotor in a continuous cycle.

Most alternators are designed to ensure an explosive mixture of hydrogen and air is never reached inside the system by pressurizing it to approximately 2 bar g (30 psi g), thus ensuring that air is unable to leak "into" the alternator casing and contaminate the hydrogen. Another important consideration is to keep the hydrogen from leaking out of the alternator, mixing with the surrounding air and again causing an explosion risk.

The rotating ends of the alternator pass through the "end- shields" and it is that area that has to be sealed to prevent any hydrogen from leaking out. Hydrogen seals are installed on the two rotor ends where they pass through the alternator end-shields. Here oil is typically used as the sealing medium; being sprayed on to shaft around its circumference to generate the seal. This "seal oil" is supplied at a higher pressure than the hydrogen gas inside the generator casing. As such, some of the seal oil flows out of the seal area along the shaft to the "air" side of the generator and some of the oil flows out of the seal area along the shaft into the "hydrogen" side of the generator.

The oil that's used as the "seal oil" is generally the same lubricating oil that's used for the bearings. That oil is normally in contact with air when it's in the lube oil tank and the bearing drains. So, air (in the form of small bubbles) can be entrained in the lube oil, and when sprayed on the generator shaft that air can be liberated from the oil that flows into the hydrogen side of the seal area. This air, if not monitored, could continue to collect inside the generator casing and reduce the purity of the hydrogen, and cause a safety concern.

If the hydrogen purity drops below a certain level (around 80% or so, depending on manufacturers' recommendations), then the alternator is usually stopped and purged of hydrogen.



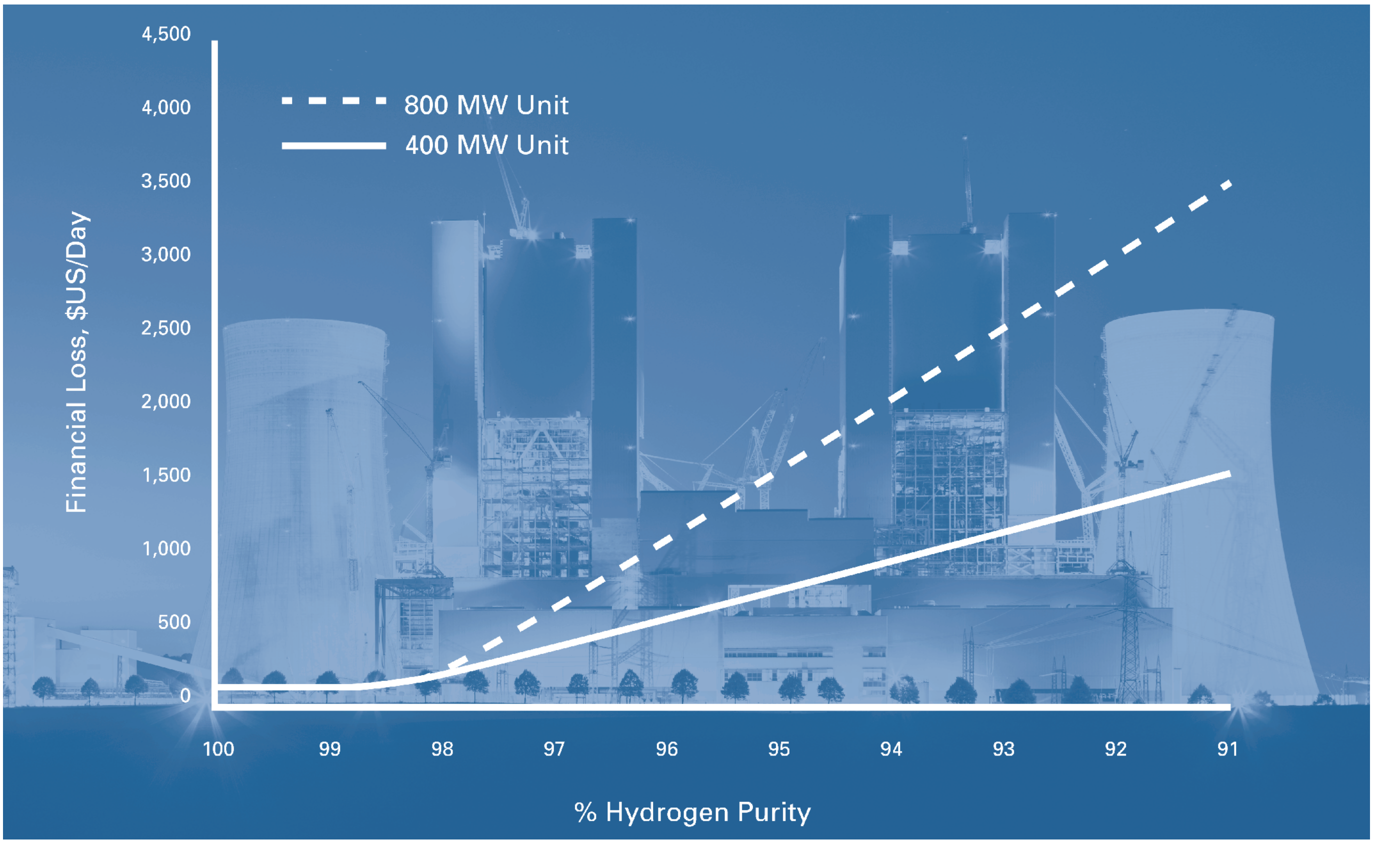
Why measure your gas makeup?

It is important to understand the composition of your coolant gas stream across the various operation and purge gas cycles in the process for a number of key reasons:

The first and most important is to ensure the safe operation of the generator. Accurate measurement of hydrogen purity is essential to provide an early warning of a potentially explosive mixture of hydrogen and air.

The second is the economic impact of reduced efficiency. To increase plant productivity and control generating cost per megawatt, turbine generators must perform with optimum efficiency. A drop in the hydrogen purity causes additional windage losses and consequently reduces the generator efficiency.

The payback from purity enhancement is immediate and impressive, with the following plot showing how decreasing hydrogen purity levels can directly impact the plant economics:

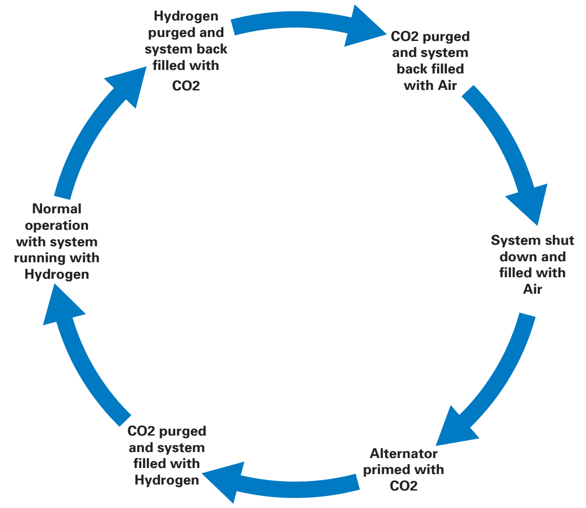


How the system is purged?

During the commissioning and de-commissioning of the alternator it is essential that the hydrogen is safely introduced and purged from the turbogenerator.

To avoid an explosive mixture of air and hydrogen during commissioning, air must first be purged from the system by an inert gas; carbon dioxide is in common use for this purpose although the use of argon or nitrogen is gaining in popularity. The hydrogen coolant is then introduced and replaces the purge gas.

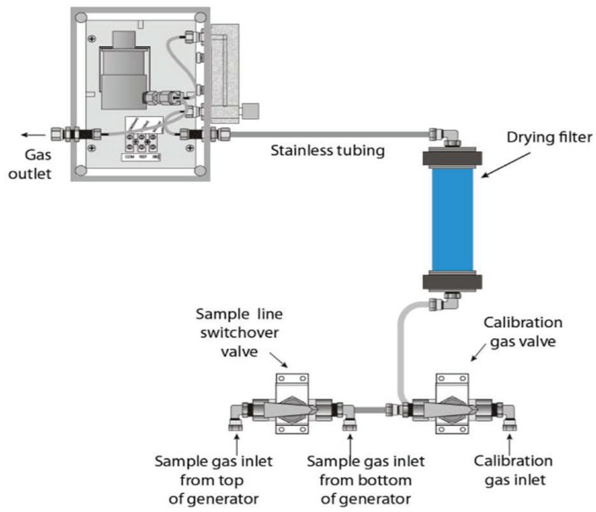
To de-commission the turbo generator the purge sequence is reversed.



How best to measure your sample gas?

Selecting the correct analyser to match your process requirements is only part of the solution. Ensuring your installation is configured correctly is critical to the accurate, reliable and trouble free operation of your plant.

Our experienced application specialists are available to offer technical support and assist in the design and development of tailored sample conditioning systems.



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What we offer?

Our alternator purge analyser range has been developed with the specific requirements of power plant customers in mind. Over the past 30 years, we have worked closely with Plant Operators, OEMs and Generator manufacturers alike to develop the latest generation of alternator purge instruments.

Key benefits we can offer include:

- A proven solution from the industry specialists with over 30 years experience in manufacturing hazardous area gas analysis equipment.
- Our unique non-depleting katharometer technology; utilises a multi-function sensor capable of measuring the hydrogen and carbon dioxide concentrations across the various purge cycle phases for optimum performance and durability.
- Our fully ATEX compliant designs allow the instruments to be installed in the widest variety of locations.
- Portable instruments are available to provide for instrument redundancy.
- Extensive range of retrofit kits are available for "plug and play" upgrading from competitor products.
- With no maintenance or consumable parts, our analysers are designed for trouble free operation. To complement this, our sensor overhaul kits are readily available and competitively priced, making the cost of ownership significantly less than that of rival products.
- Extensive range of Intrinsic Safety, Industrial Network, Visualisation and Surge Protection accessories to complement our range of gas analysers, all from the same supplier.
- As part of the global Crouse-Hinds by Eaton business and with our regional offices and global distributor network we are well positioned to assist you and your customer needs wherever they may be.

MTL part of Eaton's Crouse-Hinds business are world leaders in the development and supply of Intrinsic Safety, Industrial Networks, Visualisation and Surge Protection products. Our product range, part of Eaton's Crouse-Hinds portfolio, are now united with Eaton's leading range of reliable, efficient and safe electrical power management solutions.

With over 30 years of gas application experience, our installed base includes supplied equipment used in digester gas analysis, landfill gas monitoring, CDM verification, gas-to-grid, CHP engine protection and efficiency and flare stack monitoring.

Application specific analysers are our forte. Rather than modify an existing product, we have designed application specific analyser solutions for power stations, the chlor alkali industry and biogas plants. This approach ensures that every component is chosen for the job and performs accordingly. For further details on this or any other of our gas products, including detailed application guides, reference lists, presentations, please visit our website or contact us directly at mtlgas@eaton.com

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