Swiss Biogas Engine

Presented By

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Alpine Energy Systems

Background

- Alpine Energy Systems is a Southern California Distributor
- Swiss Cogeneration System based on Liebherr engine produced in Bulle, Switzerland
- Manufactured by Avesco AG of Langenthal, Switzerland (www.avesco.ch)
- Avesco one of largest privately-held companies in Switzerland
- Avesco is mostly known as the Caterpillar distributor for the entire country of Switzerland

Liebherr Gas Engines

- Liebherr has produced industrial engines for many years
- Engines known for durability and efficiency
- Engine can operate on biogas, natural gas or a combination thereof
- V8 Engine (400kw)
- V12 Engine (600kw)

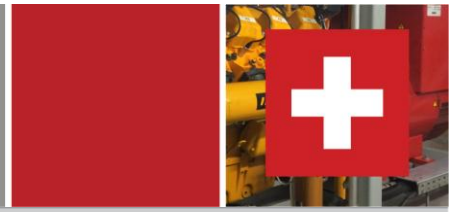
The Emissions Technology

- Liebherr sponsored research at the Technical University of Zurich
- Response to tougher emissions regulations in the Canton of Zurich
- Research focus was the use of exhaust gas recirculation coupled with a 3 way catalytic converter
- Engine is supercharged and intake mixture aftercooled (stoichiometric mixture)
- Engine knock no longer a limiting factor in emissions reduction like lean burn engines
- Research led to technology patented around the year 2000

Commercial Application of Technology

- Approximately 21 installations at wastewater treatment plants since 2006
- Several natural gas installations at hospitals, district heating networks, etc.
- Many successful years of operating history
- Turnkey servicing programs

Recent Testing in Switzerland



- July 8, 2014 at the Frauenfeld Wastewater Treatment Plant
- Liebherr V8 (250kw) engine
- Biogas cleaning system (activated carbon)
- Emissions testing performed by Total Air Analysis, Inc.
- Testing according to established EPA protocols

Summary of Results

- **Facility:** Frauenfeld, Switzerland WWTP
- **Source:** Liebherr 250 KW GenSet
- **Date:** 7/8/2014

Parameter/ Condition Run No.	Units	1	2	3	Limits SCAQMD	Pass/Fail
NOx **NOx @ 15% O_2**	ppmv ppmv	3.28 **0.93**	1.98 **0.56**	1.09 **0.31**	**Rule 1110.2** **11**	**Pass**
CO **CO @ 15% O_2**	ppmv ppmv	78.75 **22.36**	53.68 **15.25**	27.48 **7.80**	**250**	**Pass**
Total Hydrocarbons **Methane** **TOC, non-methane** **TOC @ 15% O_2**	 ppmv ppmv ppmv	 – – –	 432 2.00 **0.57**	 – – –	 **30**	 **Pass**
O_2	%	0.00	0.00	0.00	–	_
CO_2	%	11.70	11.70	11.70	–	_

Conclusion

- Test demonstrated viability of low emission engine running on biogas
- Importance of biogas cleaning system to preserve catalyst
- Catalyst subject to routine cleaning on multiple occasions before replacement
- Economical operation with proper maintenance