

全球最佳实践  
大中等规模沼气工厂技术规划与设计II



Middle-Large Scale Biogas-Plant-technology  
Planning and Design II  
热电联产模块的设计  
Design of CHP modules

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北京, 2010-05-15

Beijing, May 15, 2010

# Engineering of gas engines

## 气体发动机工程

A biogas engine consist from a lot of different pieces. Examples are ranging from container with stack to cooling water and exhaust gas heat exchangers to turbo charger. And all is related to safety requirements. This presentation tries to cover several technical items but can not be complete as a gas engine is too complicated to be completely discussed within 1,5 hours only.

气体发动机有很多部分组成。例如带柱状装置冷凝水的热电联产集装箱以及涡轮机废气热交换装置。而所有这些都需考虑到安全要求。这个报告涉及到一些技术问题，在这仅仅的1.5小时内，我们不能涉及到燃气机的具体问题，因为燃气机非常复杂。

# Krieg & Fischer Ingenieure GmbH

## 克里格与菲舍尔工程有限公司



Engineering Office, specialized in Design and Engineering of Biogas Plants 工程处：专业从事沼气工程的设计与工程

Foundation: 1999 成立时间：1999年

Team: 18 团队：18个

Experience: > 20 Years 经验：>20年

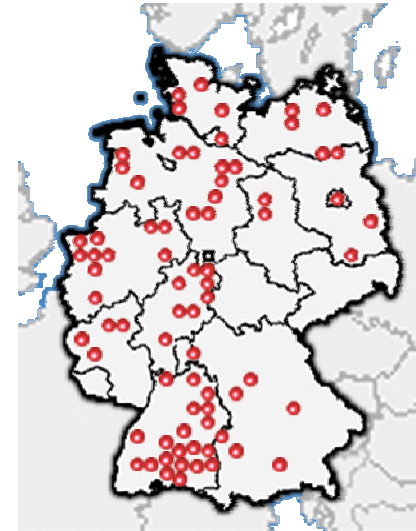
References: ca. 140 Biogas Plants 案例：140个沼气工厂

in: Germany, Japan, Netherlands, Austria, Switzerland, Lithuania, Italy, Slovakia, Canada, USA, Spain, France, Ireland

工程所在地：德国，日本，荷兰，荷兰，澳大利亚，瑞士，立陶宛，意大利，斯洛伐克，加拿大，美国，西班牙，法国，爱尔兰

Partner: Japan, Korea, USA, Canada, Bulgaria, France, Hungary, Turkey, Poland, Italy, Spain, Ireland, Serbia

合作者：日本，韩国，美国，加拿大，保加利亚，法国，匈牙利，土耳其，波兰，意大利，西班牙，爱尔兰，塞尔维亚



## Krieg & Fischer Orders at this Moment (April, 2010) 公司目前的订单 (2010-04)



in France, Spain, Italy, Ireland, USA, Germany, Norway,  
Serbia, Poland und Canada, The Netherlands,  
United Kingdom and Finland.

法国、西班牙、意大利、爱尔兰、美国、德国、挪  
威、塞尔维亚、波兰、加拿大、荷兰、英国、芬兰

## Torsten Fischer 弗林斯菲舍尔

- President of Krieg & Fischer Ingenieure GmbH 克里格与菲舍尔工程有限公司总裁

→ Founded by Andreas Krieg and Torsten Fischer in 1999

由安德烈亚斯·克里格和弗林斯·菲舍尔创立于1999年



- Education: Engineer for Shipbuilding Construction 教育：造船结构工程师

- Experience in the field of biogas since 1992 自1992年开始从事沼气领域的工作

→ **Special fields:** - waste management and municipal engineering  
- safety aspects of biogas plants

→ 专长：废物管理与市政工程；沼气工厂的安全问题

- **Lecturer** at the University of Höxter and Gießen 赫克斯特和吉森大学讲师

- Accreditation of the Chamber of Engineers of Germany as  
**Expert Witness in the field of biogas** 作为沼气领域的专家参与德国

工程师库的评审



Service offerings of Krieg & Fischer  
in the field of Biogas

在沼气领域的服务产品



- Studies 研究
- Concept Development 概念开发
- Calculations 计算
- Permits & Approvals 许可证与认证
- Engineering 工程
- Tendering and Commissioning 招标与调试
- Construction 建设
- Start-up 启动
- Optimization/Retrofits 优化/改造
- Supervision and Consulting 监督与咨询

# References – Examples 参考-示例



Central Biogas Plant

中央沼气厂



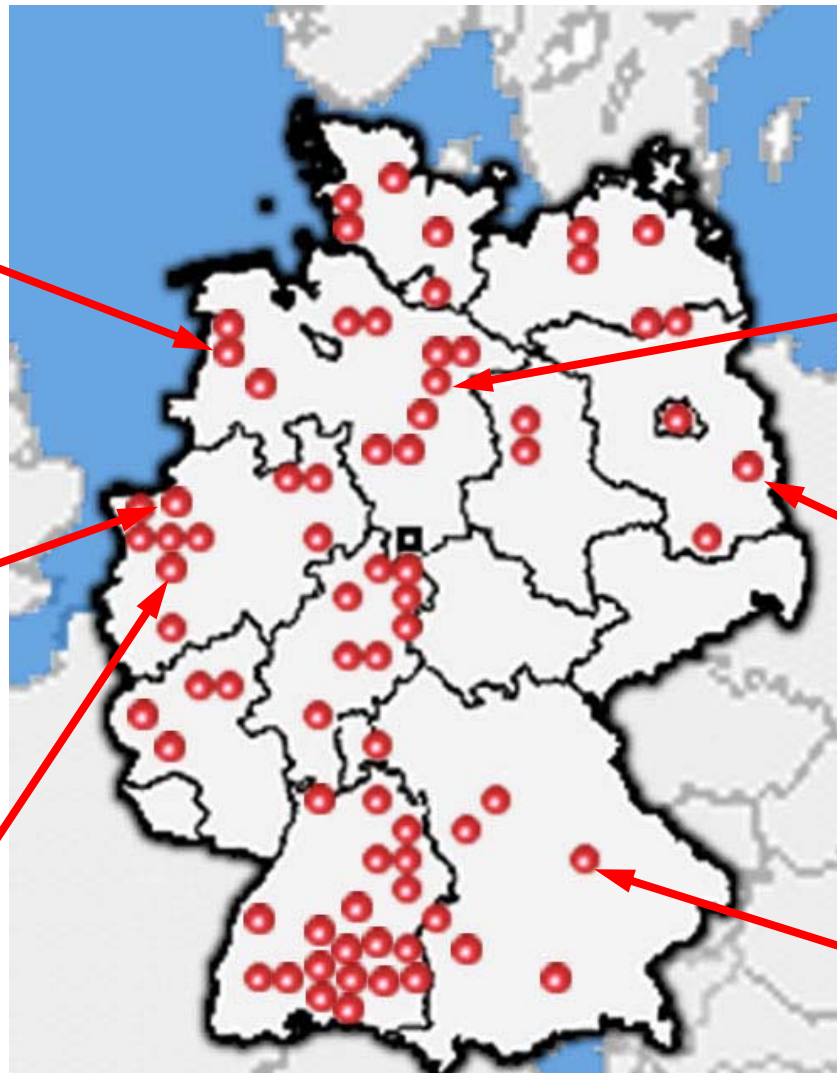
Energy Crop Biogas Plant

能源作物沼气厂



Kitchen Waste Digestion

厨房垃圾消化



Potato Residue Digestion

马铃薯残渣消解



Energy Crops with Cattle Manure

牛粪为能源作物



Biowaste Digestion

生物残渣消解

Werlte,  
Germany  
德国，韦尔特



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Built: 2002 建造：2002年

Input: 输入：

manure (粪肥) 90,000 m<sup>3</sup>/a,  
fats (油脂) 20,000 m<sup>3</sup>/a

Digester 2 x 3,200 m<sup>3</sup> steel  
tanks 消化池：2 x 3,200 m<sup>3</sup> 钢罐

CHP: 2 x 1,3 kW<sub>e</sub> gas engine  
电联产：2 x 1,3kW<sub>e</sub> 气体发动机

Gasholder above secondary  
digester, heat usage

二级以上沼气池储气罐，热量利用



## Im Brahm, Germany



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- Built: 2005 建造: 2005
- Input: kitchen waste, pig manure, horse dung  
输入: 厨房垃圾, 猪粪, 马粪
- Digester: 1,205 m<sup>3</sup> concrete tank  
消化池: 1,205 m<sup>3</sup> 混凝土罐
- CHP: 2 x 190 kW<sub>e</sub> gas engine  
热电联产: 2 x 190 kW<sub>e</sub> 气体发动机
- Mesophilic process engineering with hydrolysis  
中温水解过程工程

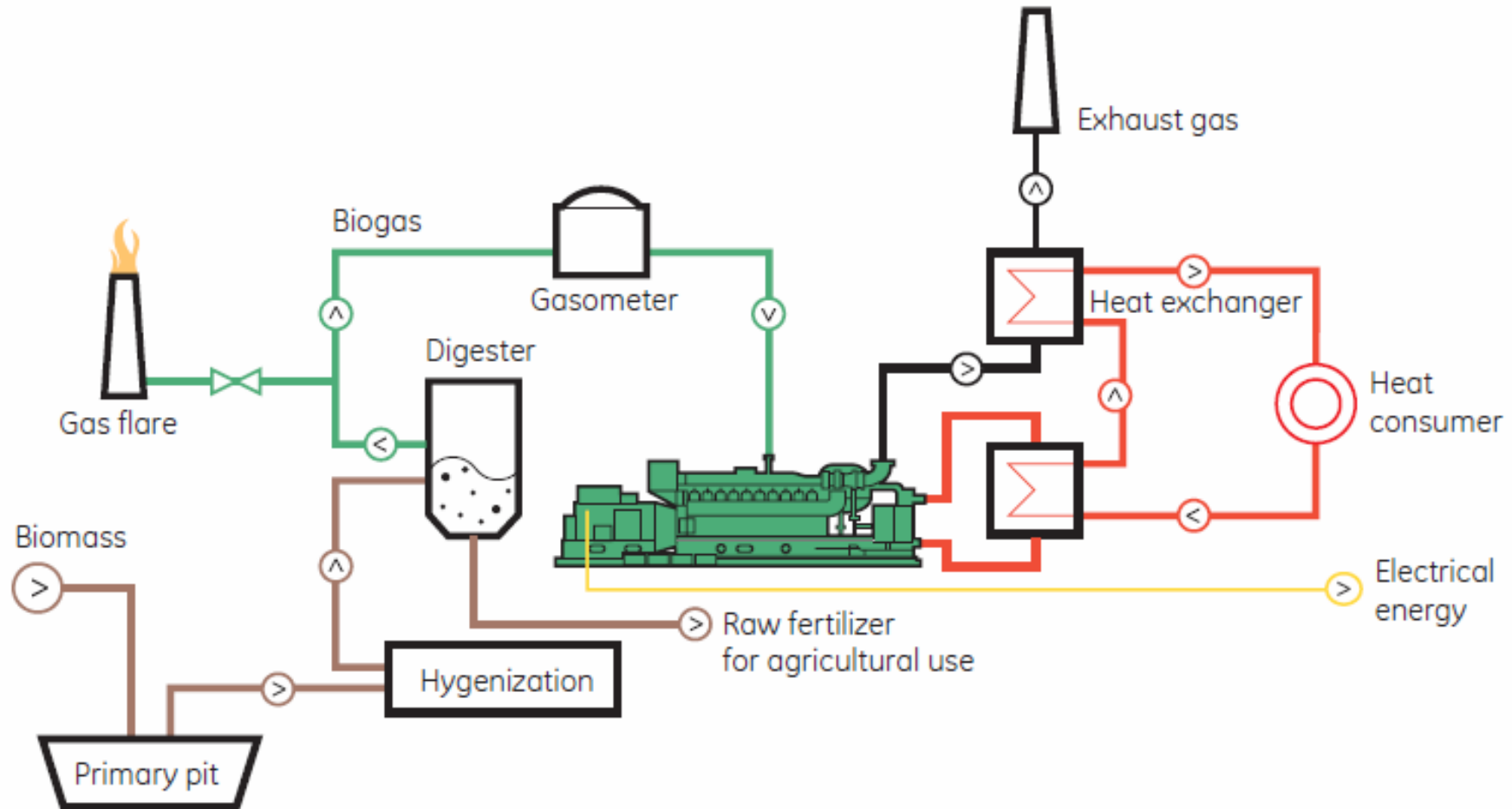
## Combined Heat and Power Plant 热电联产工厂



- Introduction CHP 热电联产介绍
- Safety 安全性
- Container / Building 装置/建筑物
- Pretreatment of biogas / Exhaust gas emission 沼气预处理/废气排放
- Special parts 特殊部分
  - Blower 鼓风机
  - air input output 空气输入输出
  - lubrication oil tanks 润滑油箱
  - heat utilization 热能利用
  - Control 控制
- Noise emission 噪音
- Start-up 启动
- Maintenance, spare parts, maintenance contract 维修, 备件, 维修合同
- Mode of operation 操作模式
- Different types of CHP 不同类型的热电联产

# Introduction CHP 热电联产工厂介绍

## Combined Heat and Power plant

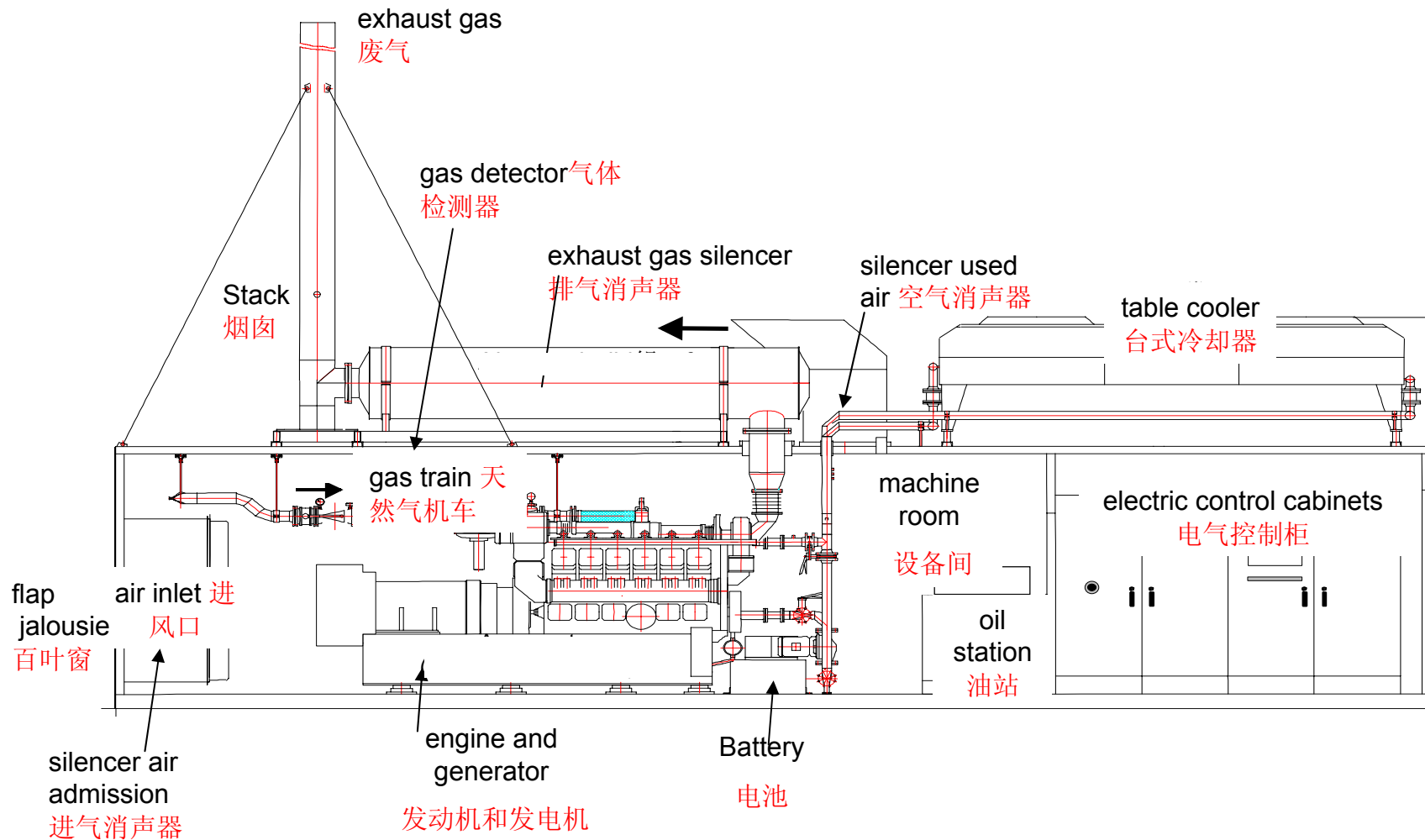


# Introduction CHP 热电联产工厂介绍

## Combined heat and power plant

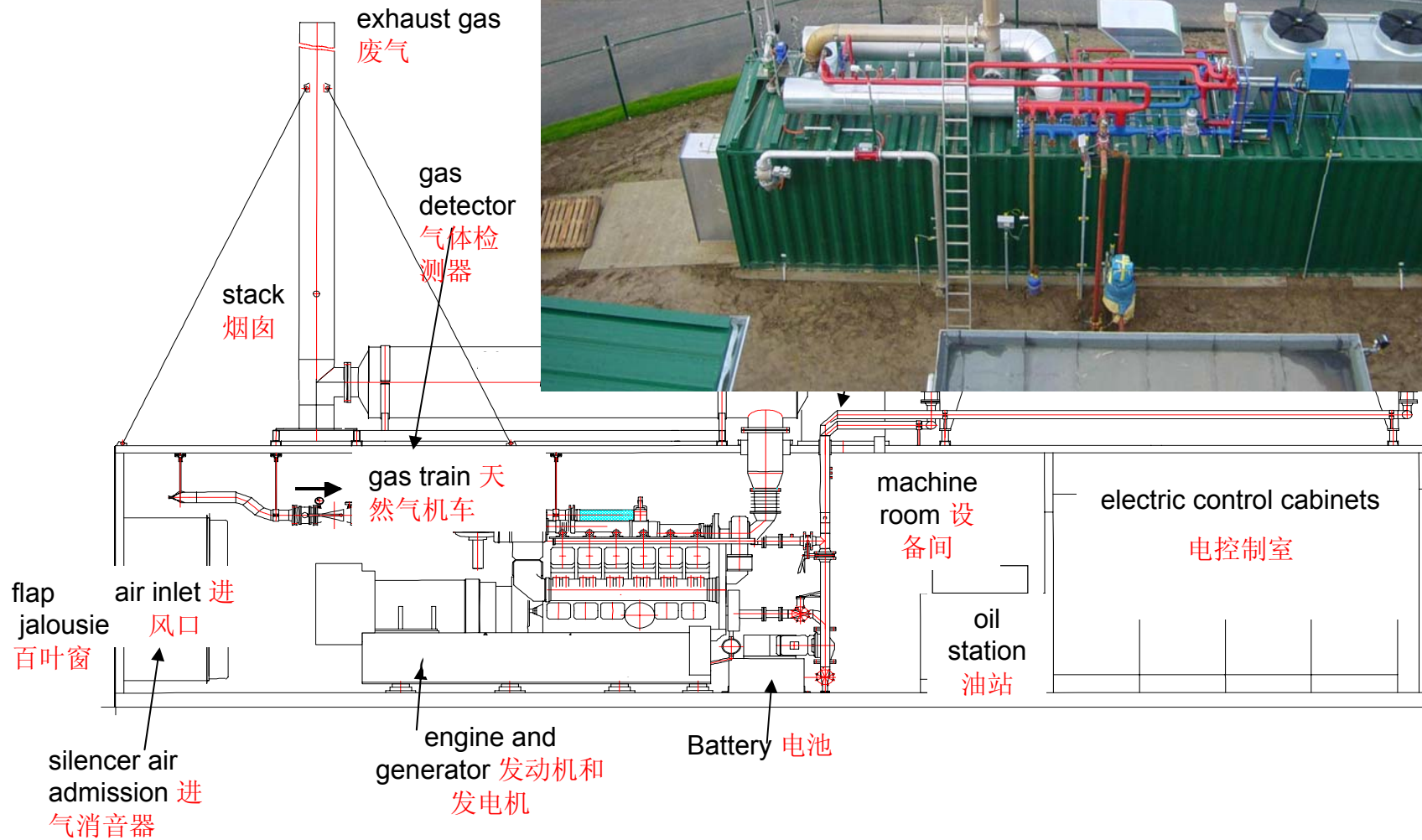


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# Introduction CHP 热电联产工厂介绍

## Combined heat and power plant



## Combined Heat and Power Plant 热电联产工厂

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# Safety

## Biogas 沼气的安全性

### Typical composition of biogas<sup>[8]</sup>

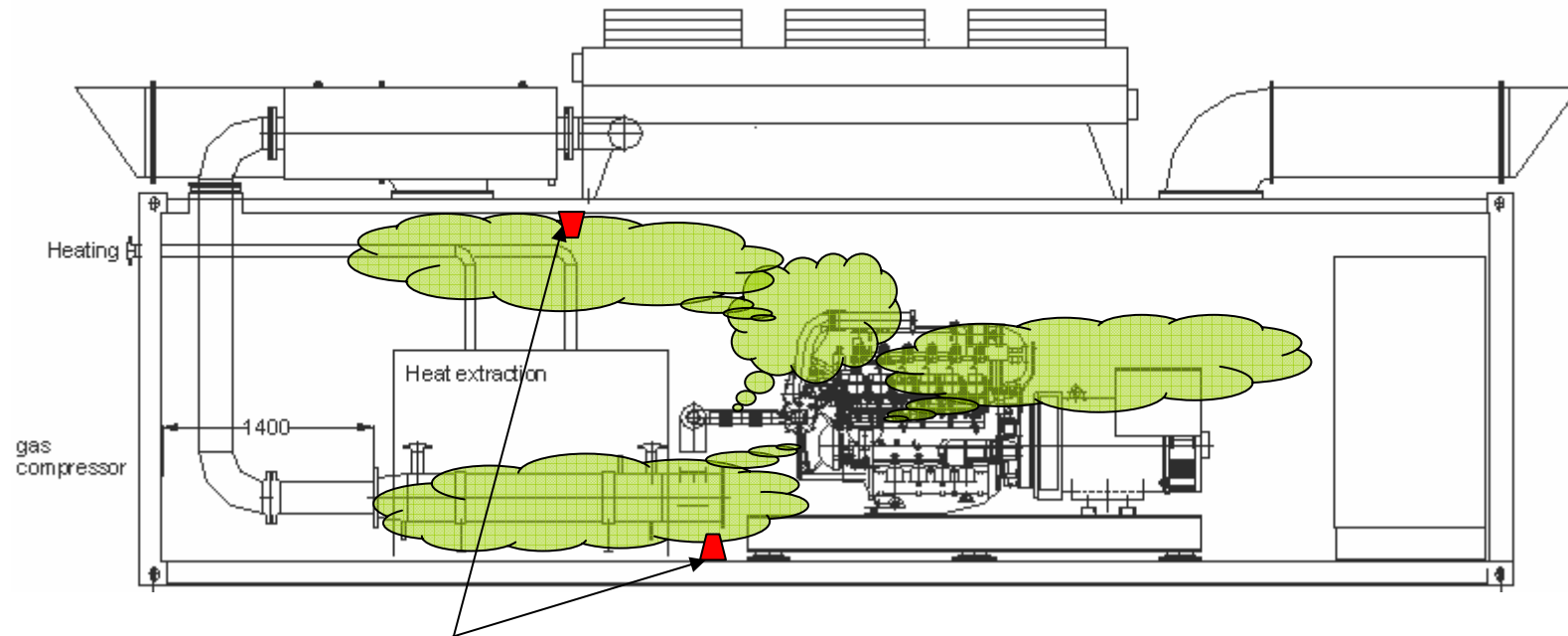
Compound	Chem	%
Methane	CH <sub>4</sub>	50–75
Carbon dioxide	CO <sub>2</sub>	25–50
Nitrogen	N <sub>2</sub>	0–10
Hydrogen	H <sub>2</sub>	0–1
Hydrogen sulfide	H <sub>2</sub> S	0–3
Oxygen	O <sub>2</sub>	0–2

Density biogas 沼气密度 (60% CH<sub>4</sub>, 40 % CO<sub>2</sub>): 1,18 kg/m<sup>3</sup>

Density methane 甲烷密度: 0,72 kg/m<sup>3</sup>

Density carbon dioxide 二氧化碳密度: 1,98 kb/m<sup>3</sup>

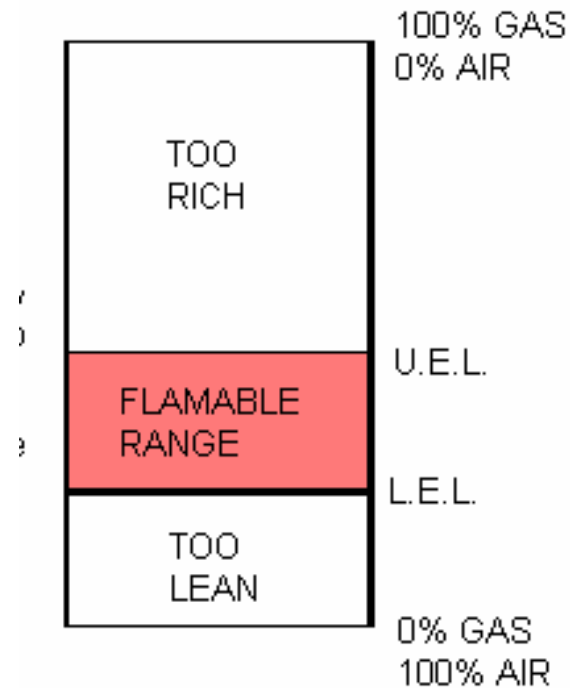
# Gas warning system 气体报警系统



Gas detector 气体检测器



# Safety Lower and Upper Explosive Limit 安全性 上下爆炸极限



Explosive limits give the proportion of combustible gases in a mixture, between which limits this mixture is flammable.

爆炸极限给出了可燃气体的混合比例，在这个范围内混合气体是可燃的

LEL - Lower explosive limit

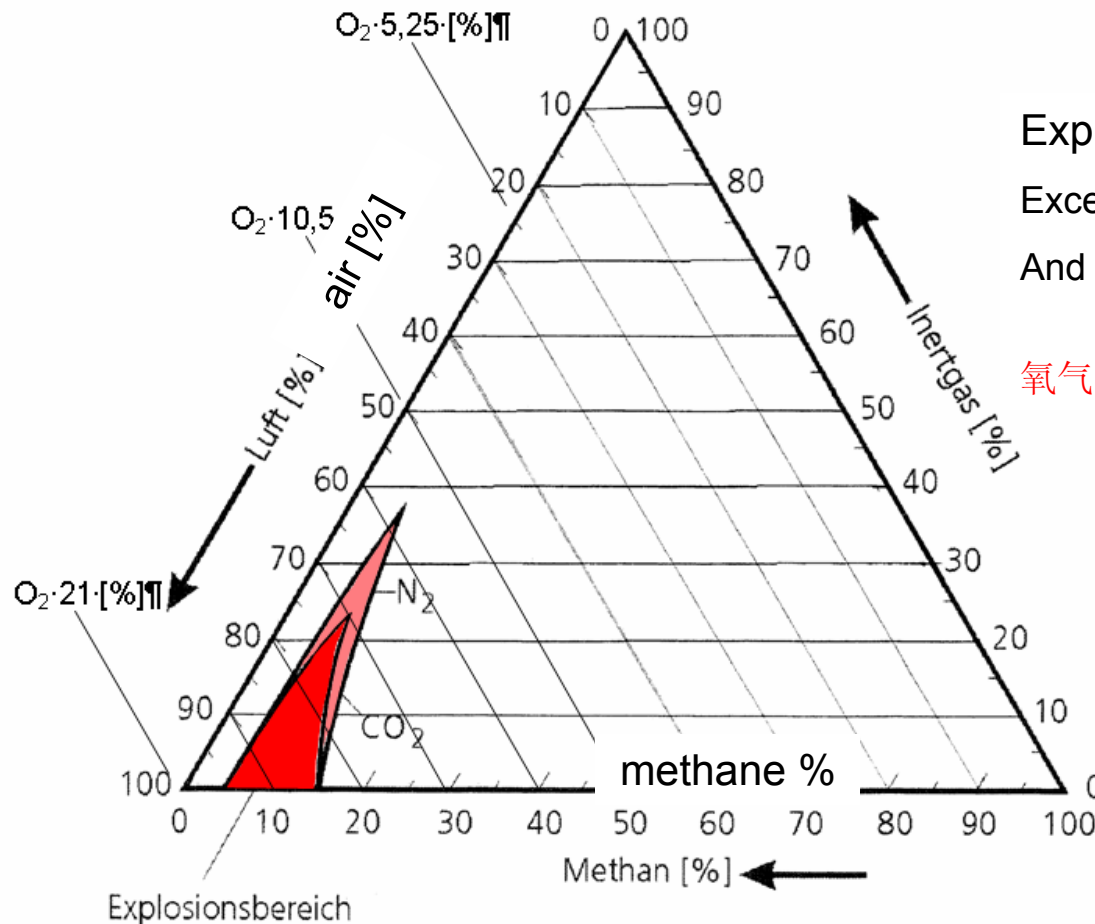
爆炸下限 4,4 – 5 Vol% CH<sub>4</sub>

UEL - Upper explosive limit

爆炸上限 15 -17 Vol% CH<sub>4</sub>

# Safety 安全性

## Lower and Upper Explosive Limit 上下爆炸极限



Explosion area: 爆炸区域:

Exceeding of 11,6 Vol% oxygen

And between 4,4 Vol% methane (100% LEL) and 16,5 Vol% methane (100% UEL)

氧气的含量超过11.6%，甲烷含量在4.4%-16.5%之间

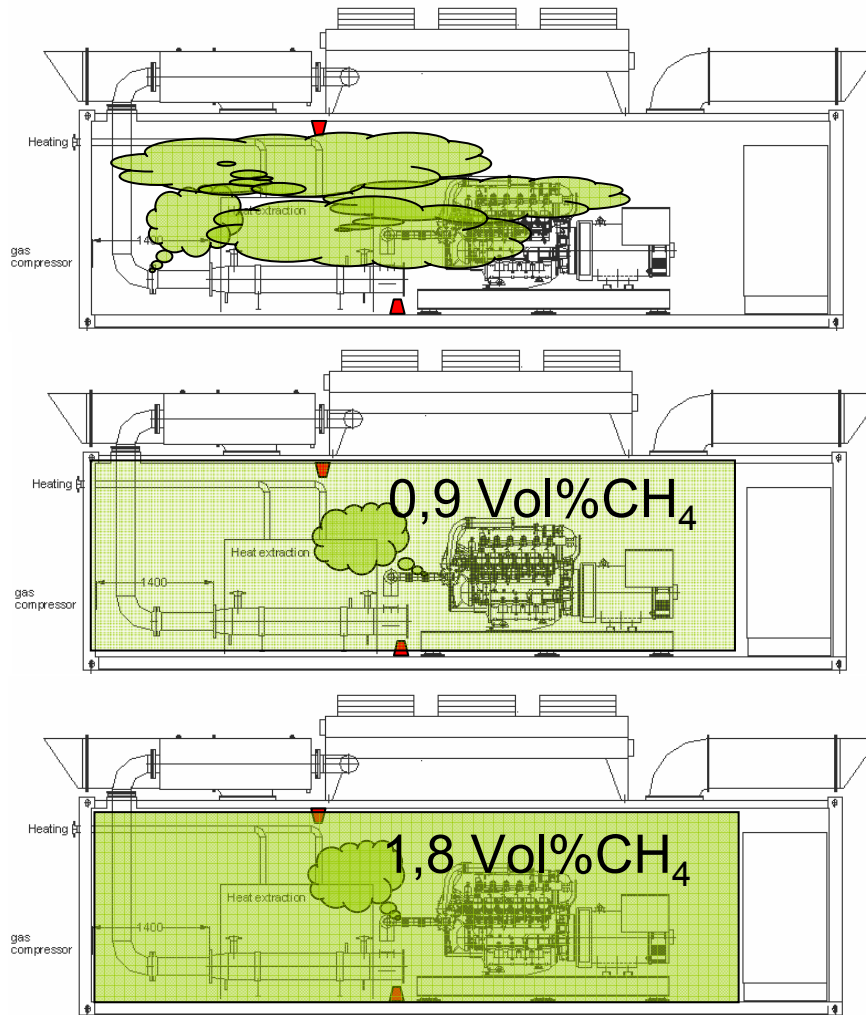
source: after Tabarasan /  
Rettenberger – UBA  
Forschungsbericht 12/1982, Nr.  
1030227 Teil 1

# Safety

## Gas warning system 安全性 气体报警系统



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1. Leakage of biogas 沼气泄露

2. 20% LEL reached:

达到爆炸下限的20%

→ optic and acoustic warning

光学和声学报警

→ 100% ventilation 100%通风

3. 40% LEL reached:

达到爆炸下限的40%

→ optic and acoustic warning

光学和声学报警

→ 100% ventilation 100%通风

→ automatic switch off of the

CHP 自动关闭热电联产系统

→ automatic closure of the

biogas pipe 自动关闭的沼气管道

Source: Sicherheitsregeln für Biogasanlagen

Safety 安全  
Gas warning system 气体警报系统



**Alarm**  
报警系统



Hotteln



Safety 安全

Gas warning system 气体警报系统



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Manual and automatic valves in the biogas pipe

气体管道的手动和自动控制阀门

Lorsch

# Combined Heat and Power Plant 电热联产工厂



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- Special parts 特殊部分
  - Blower 鼓风机
  - air input output 气体的输入和输出
  - lubrication oil tanks 润滑油罐
  - heat utilization 热的利用
  - Control 控制
- Noise emission 噪音污染
- Start-up 启动
- Maintenance, spare parts, maintenance contract 维护, 配件, 和维护合同
- Mode of operation 操作模式
- Different types of CHP 电热联产的不同类型

## Container / Building 集装箱/建筑

- Installation in a building 设置在建筑物中  
Installation is done on site in a building. 设置在厂房处
- Installation in a container 设置在集装箱内  
The pre installed container will be delivered.  
装好的集装箱的运输

# CHP in a container 电热联产一体化



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# CHP in a container 电热联产一体化



# CHP in a building 在一个建筑内的电热联产



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# CHP in a building 在一个建筑内的电热联产



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# CHP in a building 在一个建筑内的电热联产



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# Combined Heat and Power Plant 电热联产工厂



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## Pretreatment / Exhaust gas emission 预处理/废气排放



Utilization in a CHP: 电热联产的应用

Protection of engine and reduction of emissions  
发动机的保护和排放物的减少

- Biological desulfurization 生物脱硫
- Activated carbon filter (chemical contaminations as hydrogen sulfide, siloxane)  
活性炭过滤器（硫化氢和硅氧烷的化学污染）
- Dewatering, cooling 脱水和冷凝
- Catalyst (formaldehyde) 催化剂（甲醛·）

Link TA-Luft (english version):

[http://www.bmu.de/files/pdfs/allgemein/application/pdf/taluft\\_engl.pdf](http://www.bmu.de/files/pdfs/allgemein/application/pdf/taluft_engl.pdf)

# Pretreatment /Exhaust gas emission Desulfurization 预处理/废气排放 脱硫

- Biological desulfurization in the digester 发酵罐中生物脱硫  
A small amount of air is blown into the digester 少量气体进入发酵罐
- Biological desulfurization outside the digester 发酵罐外生物脱硫
- Chemical desulfurization in the digester 发酵罐中化学脱硫
- Chemical desulfurization outside the digester 发酵罐外化学脱硫



# Pretreatment / Exhaust gas emission

## 预处理/废气排放



Activated carbon filter

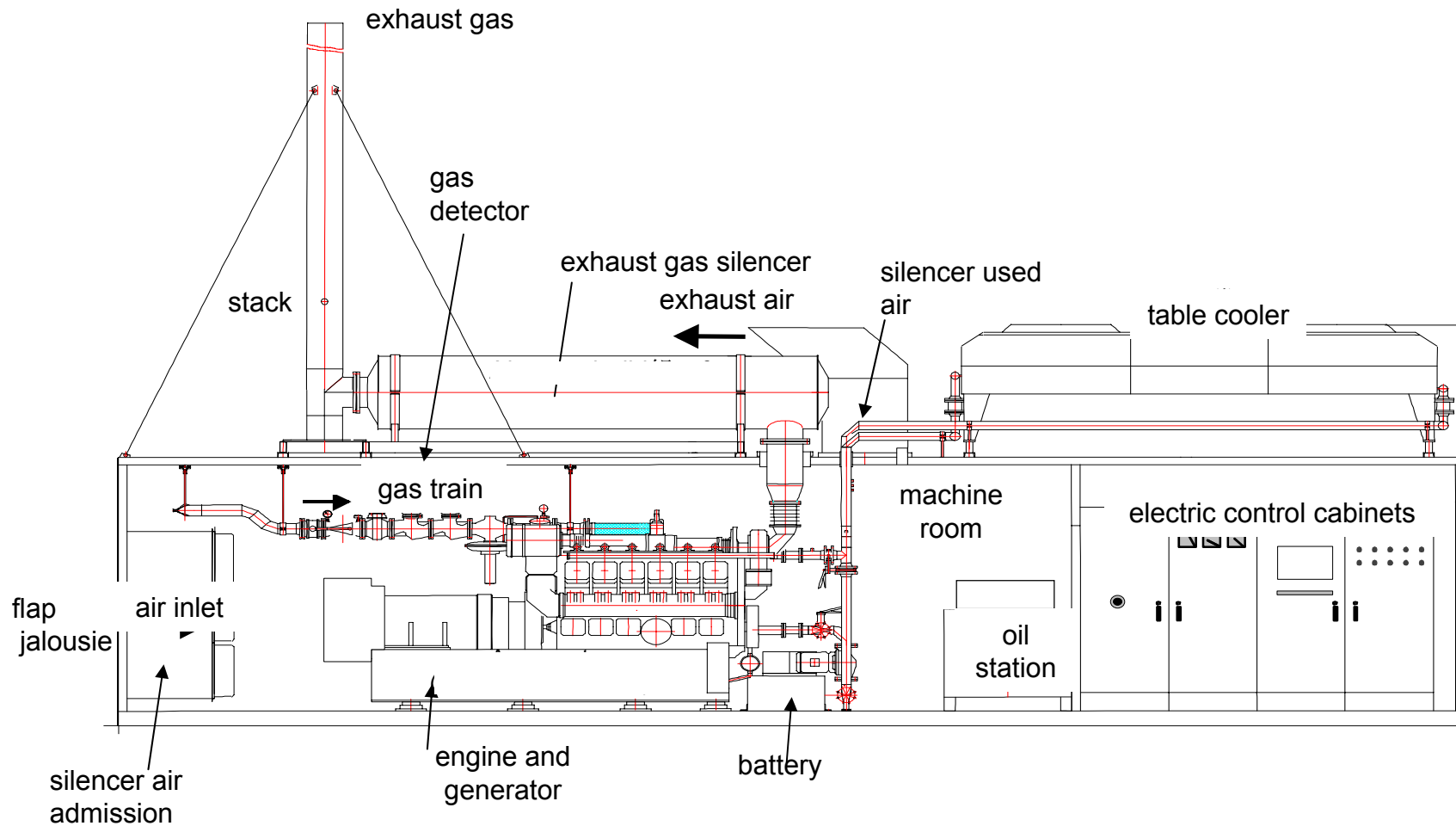


# Pretreatment / Exhaust gas emission

## 预处理/废气排放



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# Pretreatment of biogas 生物气的预处理

## Demands of the engine 发动机的要求



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Heizwert Hu	$\geq 4$	[kWh/m <sup>3</sup> <sub>i.N.</sub> ]
Heizwertschwankungen	< 1 % / 10 sec	
Methangehalt (CH <sub>4</sub> )	> 40	[Vol.%]
Methanzahl	$\geq 70 - 80$ ,	in Abhängigkeit vom Motorentyp
Methanzahlschwankung	< 1 % / 10 sec	
Schwefelgehalt, gesamt (S)	< 2200	[mg/m <sup>3</sup> <sub>i.N.</sub> ]
Schwefelwasserstoff – Gehalt (H <sub>2</sub> S)	< 0,15	[Vol.%]
Chlorgehalt, gesamt (Cl)	< 100	[mg/m <sup>3</sup> <sub>i.N.</sub> CH <sub>4</sub> ]
Fluorgehalt, gesamt (F)	< 50	[mg/m <sup>3</sup> <sub>i.N.</sub> CH <sub>4</sub> ]
Summe Chlor und Fluor (Cl + F)	< 100	[mg/m <sup>3</sup> <sub>i.N.</sub> CH <sub>4</sub> ]
Ammoniak (NH <sub>3</sub> )	< 30	[mg/m <sup>3</sup> <sub>i.N.</sub> CH <sub>4</sub> ]
Siliziumgehalt (Si)	< 10	[mg/m <sup>3</sup> <sub>i.N.</sub> CH <sub>4</sub> ]
Staub (3 – 10 µm)	< 10	[mg/m <sup>3</sup> <sub>i.N.</sub> CH <sub>4</sub> ]
Öldämpfe (> C5)	< 40	[mg/m <sup>3</sup> <sub>i.N.</sub> CH <sub>4</sub> ]
relative Feuchte (φ)	< 90	[%]
Kondensat	Kondensation im Ansaugtrakt ist auszuschließen	
Gastemperatur	10 – 50	[° C]
Gasdruck, am Eintritt Gasregelstrecke	50 – 100	[mbar](Fließdruck)
zul. Gasdruckschwankung	< +/- 10 % des Einstellwertes,	
bei einer Schwankungsfrequenz	< 1 mbar / 10 sec	

Abweichende Betriebsbedingungen sind nach Rücksprache und technischer Prüfung möglich.

# Pretreatment of biogas 生物气的预处理

## Biogas quality 生物气质量



### Example for required biogas quality from a supplier (MWM) 供应商提供的生物气质量样例

- Pressureless gas at interface 地表大气压力下气体
- Methane content: 甲烷含量 57%,
- Biogas flow rate: 气流速度 830 Nm<sup>3</sup>/h
- Biogas temperature at interface: max. 表面气体温度 40° C
- Gas humidity: 气体湿度 100%
- Average hydrogen sulfide 平均硫化氢含量 50 ppm
- During start up operation peaks till 启动阶段直到 <50 h 2,000 ppm;
- Maximum oxygen content: 最大氧气含量 2%

Pretreatment of biogas 沼气预处理

Gas cooler 气体冷却器



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Biogas is in the digester saturated with water vapor

沼气在水蒸气饱和的消化池内



Hotteln



Hehlen

1. Cooling down to ambient temperature in the storage tank and in the gas pipe  
.贮存罐和气体管道 冷却到室温
2. Gas cooling installations 气体冷却装置

Exhaust gas emission 废气排放



# Pretreatment / Exhaust gas emission Demand on Exhaust gas emission

预处理/废气排放

对废气排放量的需求



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GE imagination at work

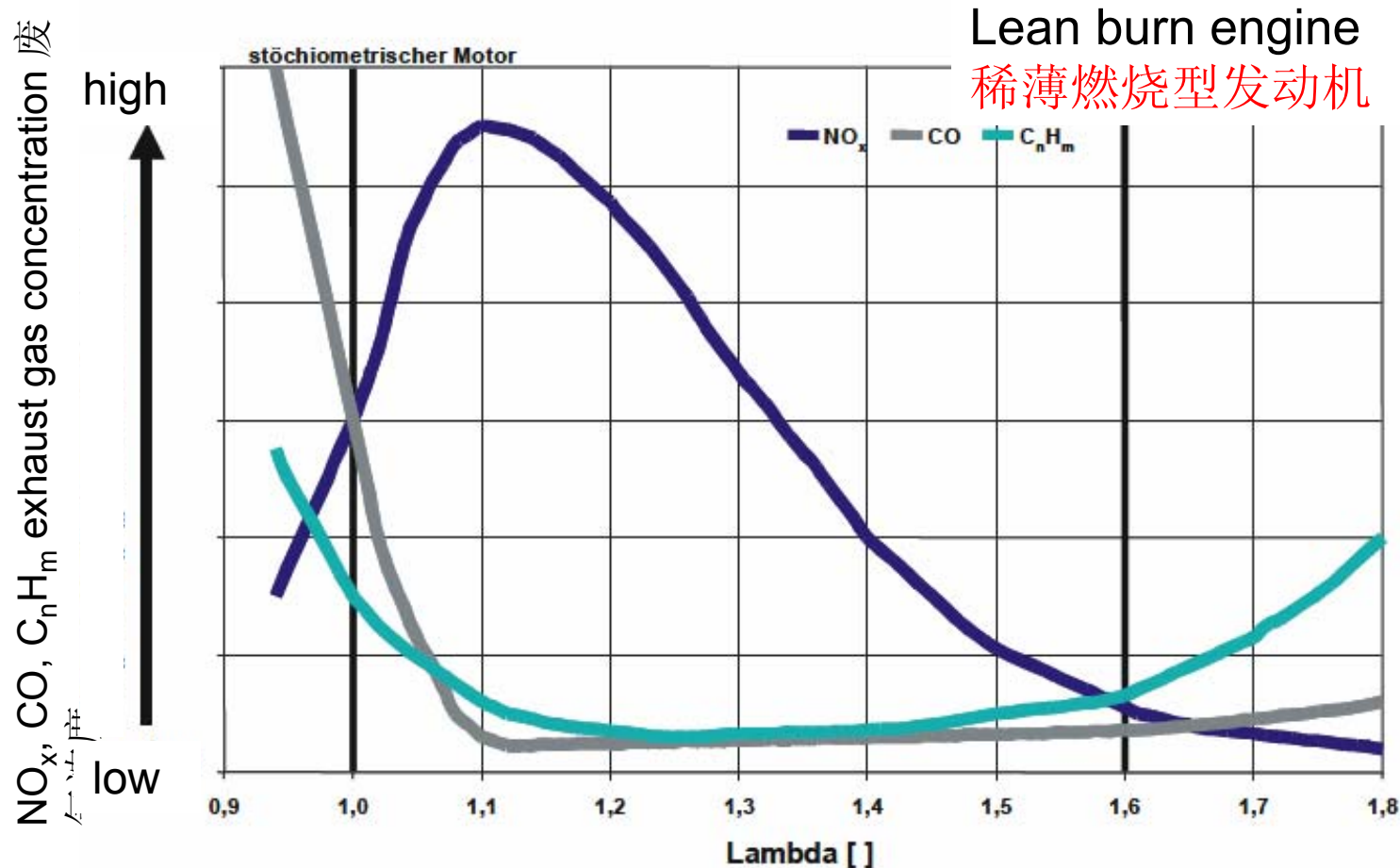
Land	Emissions-Grenzwerte (Erdgas)					Emissions-Grenzwerte (Biogas)			
	[mg/Nm <sup>3</sup> ] tr. Abgas @ 5%O <sub>2</sub>					[mg/Nm <sup>3</sup> ] tr. Abgas @ 5%O <sub>2</sub>			
	NOx	CO	NMHC	HCHO	Staub	NOx	CO	NMHC	HCHO
Austria	250 (150)	200	150 (50)			400 (500)	650 (400)	150	
Belgien - (Flandern)	( $\eta_{el}/30$ )*2600	1300							
Dänemark	550	500		(10)		550			
Finnland	467								
Frankreich	350	650	150		50	525	1200		
Deutschland	500	300		60	20	500	1000(650)		60(40)
Ungarn)	500	650							
Italien	450					450	300	150	
Japan	310/470					500			
Niederlande	438					438			
Portugal	3077	1219							
Spanien	500	950							
Schweiz	250(50)	325				400	650		
UK	( $\eta_{el}/40$ )*267					550	1400		
USA	ca. 250	ca. 1200	150			ca. 250	ca. 1200	150	

# Pretreatment / Exhaust gas emission

## 预处理/废气排放



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Dependency of the emissions on the lambda value (Herdin 2002)

在lambda函数中气体排放量的相关性 ( Herdin 2002 )

# Pretreatment /Exhaust gas emission Exhaust gas treatment

预处理/废气排放  
废气处理

- Oxidation catalytic converter  
for reduction of formaldehyde

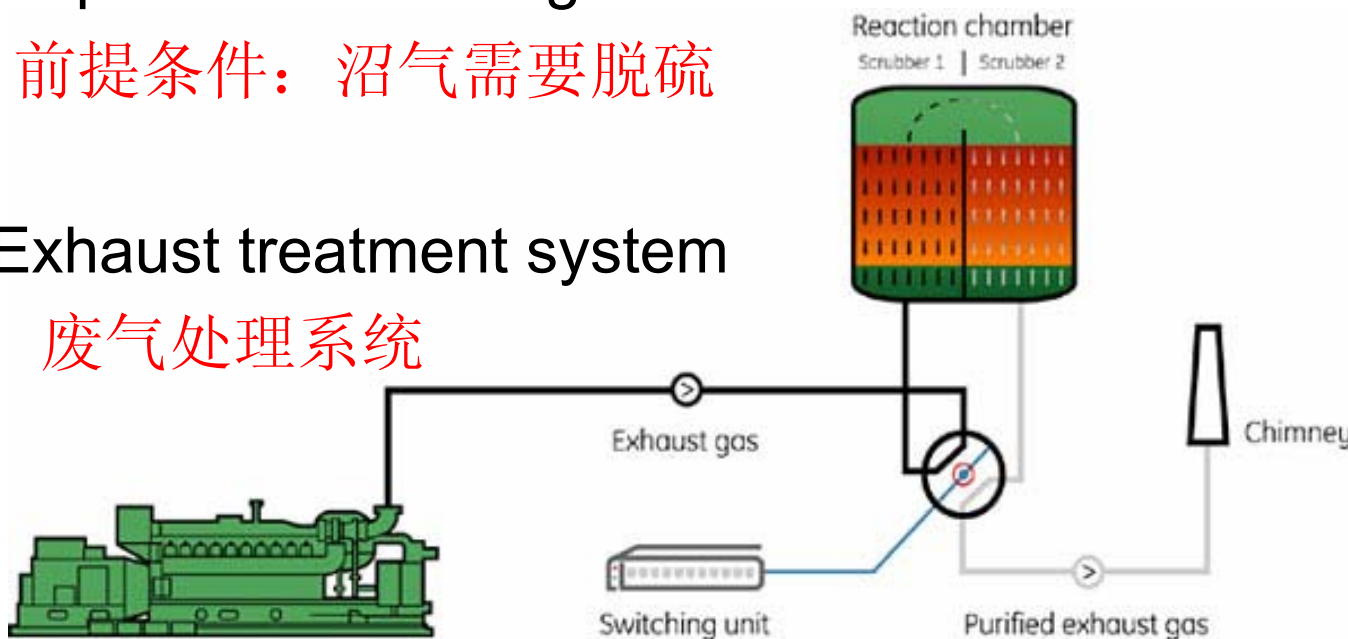
用于减少甲醛含量的氧化催化转换器

→ precondition: biogas has to be free of sulfur

前提条件：沼气需要脱硫

- Exhaust treatment system

废气处理系统



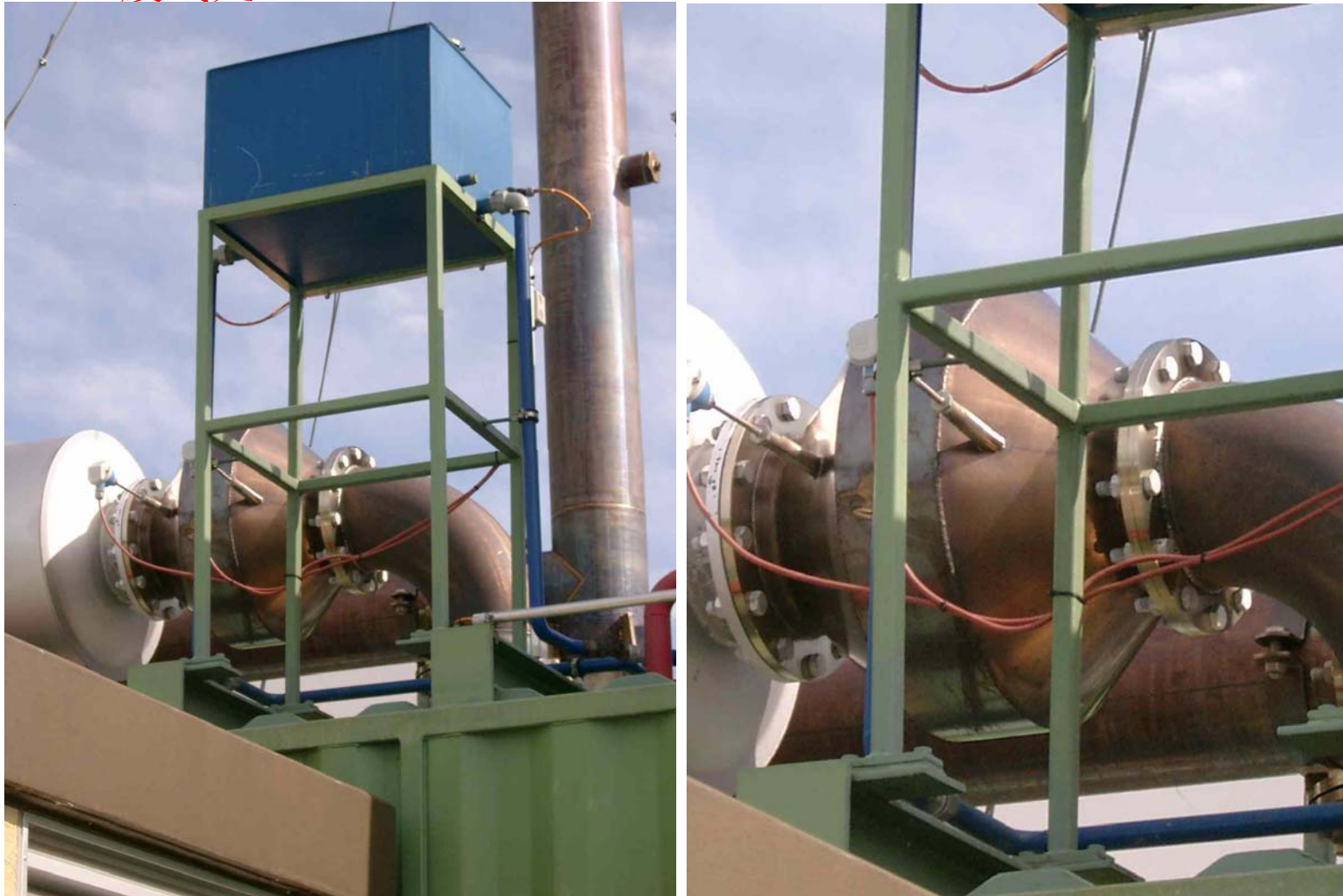


Pretreatment /Exhaust gas emission  
Exhaust gas treatment

预处理/废气排放  
废气处理



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Catalyst  
催化剂

Exhaust gas emission 废气排放  
Technical instruction on Air Quality Control  
关于空气质量控制的技术指导



same engine  
different height  
of stack

同一发动机不同的  
烟囱高度



**5.5.2 Discharge through Stacks**

Stacks shall have a minimum height of 10 m above ground level and project 3 m, as a minimum, above the ridge of the roof. In case of a roof with a slope of less than

Link TA-Luft (english version):

[http://www.bmu.de/files/pdfs/allgemein/application/pdf/taluft\\_engl.pdf](http://www.bmu.de/files/pdfs/allgemein/application/pdf/taluft_engl.pdf)

# Exhaust gas emission 废气排放



Krieg & Fischer Ingenieure GmbH



# Combined Heat and Power Plant 热电联产



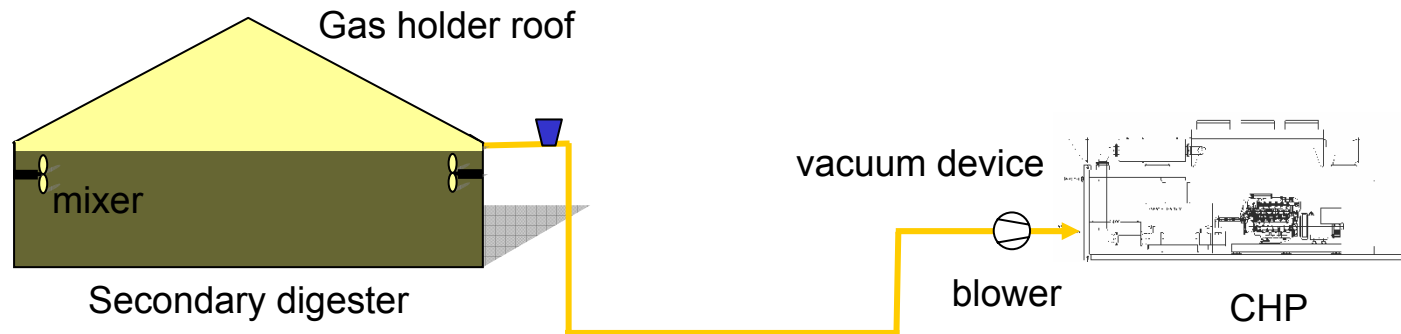
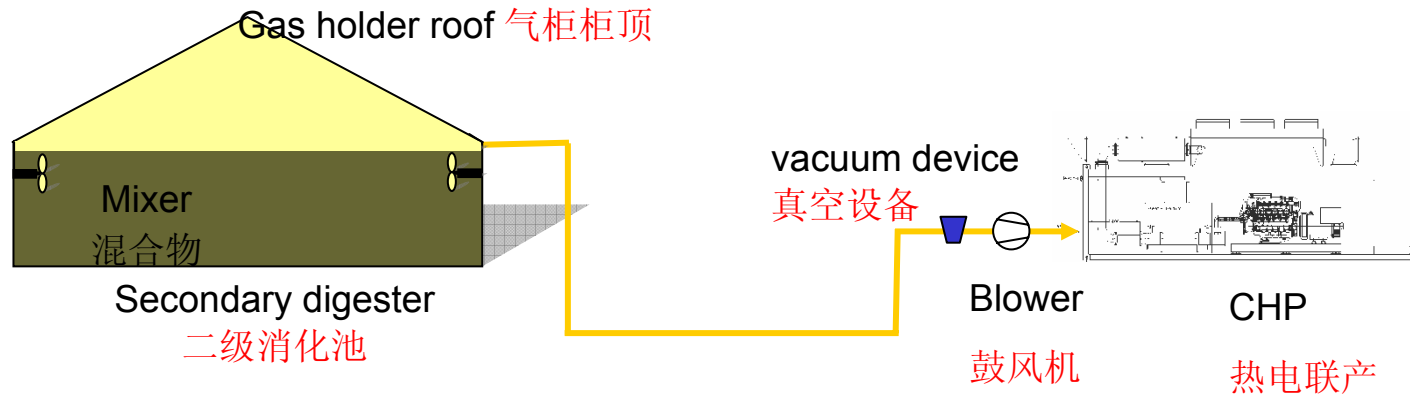
- Introduction CHP 热电联产介绍
- Safety 安全性
- Container / Building 装置/建筑物
- Pretreatment of biogas / Exhaust gas emission 沼气预处理/废气排放
- **Special parts** 特殊部分
  - Blower 鼓风机
  - air input output 空气输入输出
  - lubrication oil tanks 润滑油箱
  - heat utilization 热能利用
  - Control 控制
- Noise emission 噪音
- Start-up 启动
- Maintenance, spare parts, maintenance contract 维修、备件、维修合同
- Mode of operation 操作模式
- Different types of CHP 不同类型的热电联产

Special parts 特殊部分  
Pressure difference (pd) blower  
压力不同的鼓风机



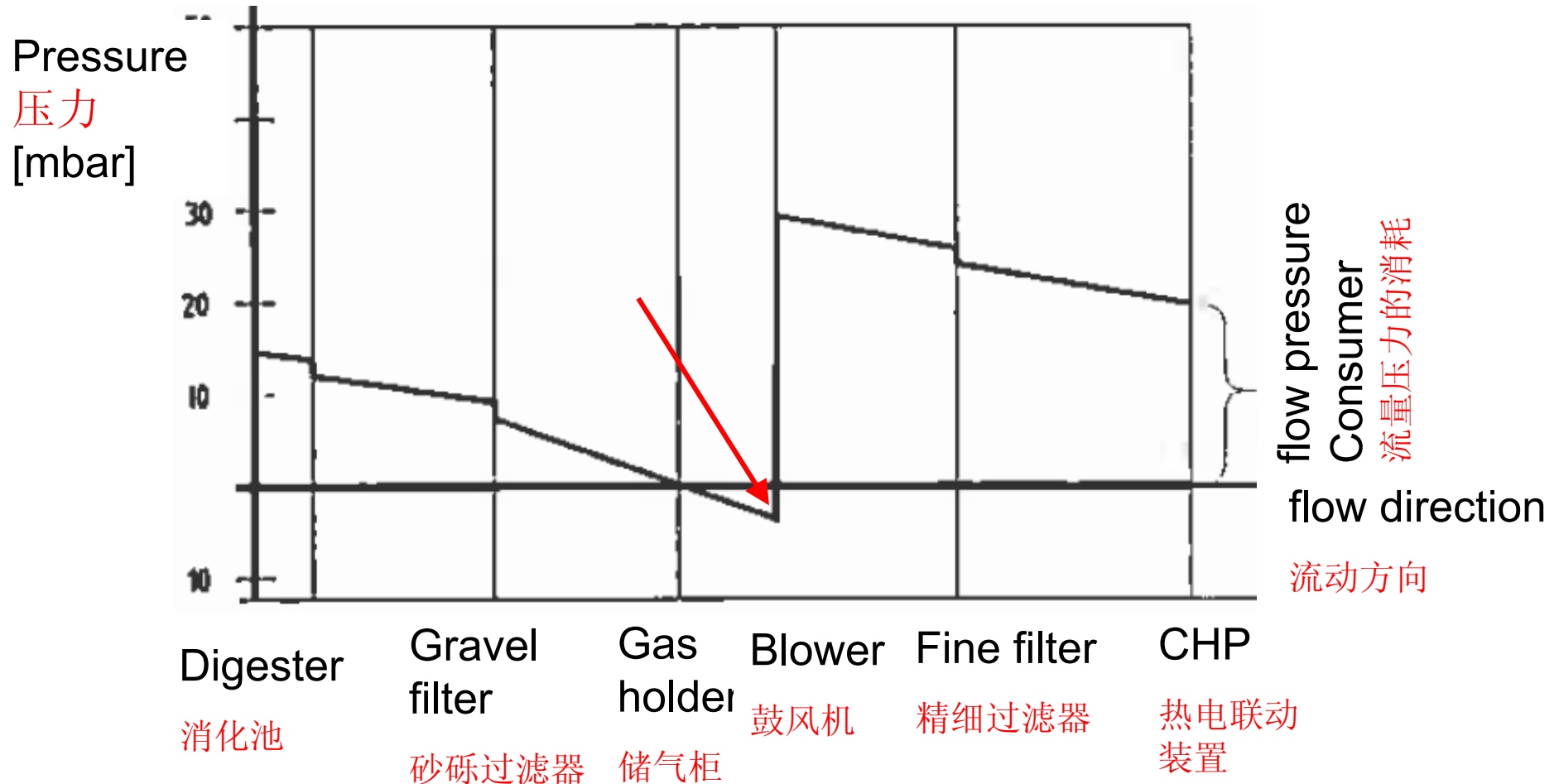
# Special parts

Blower, position 特殊部分: 鼓风机, 位置



# Development of the flow pressure in a gas system with pressureless gas holder

采用无压气柜的气体系统中流量压力的动态变化



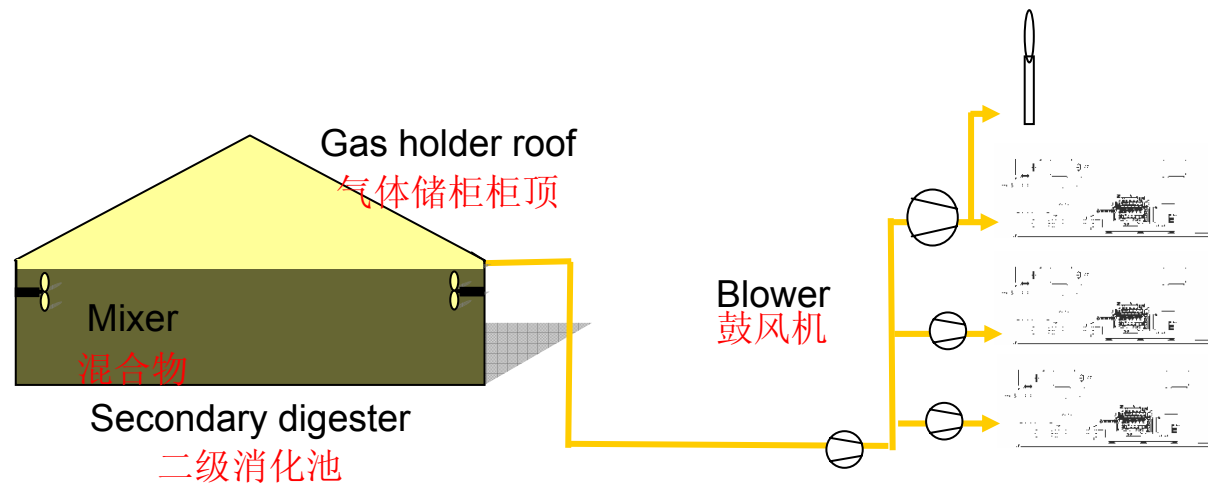
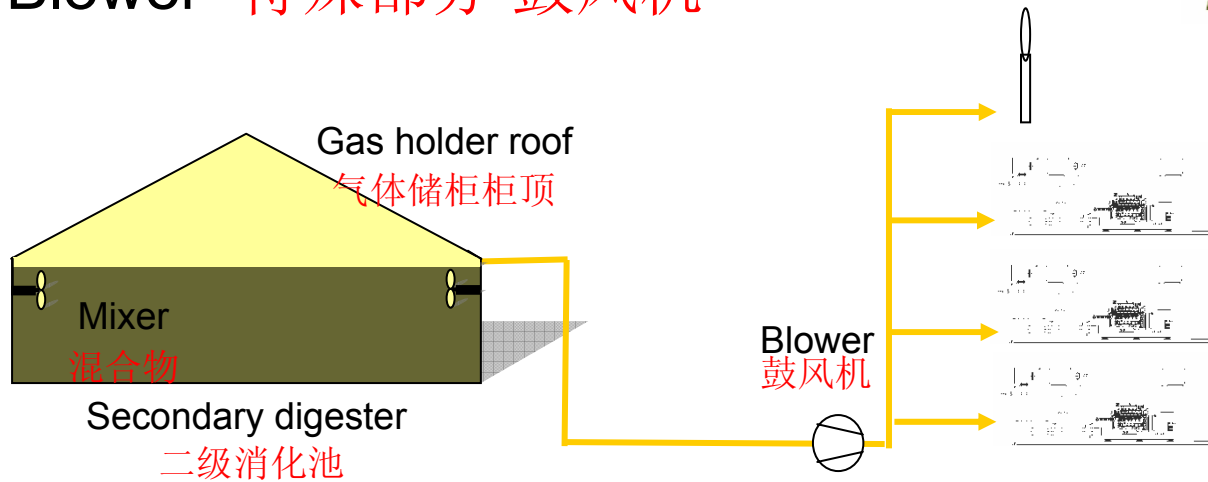
Source: Ch. Schnatmann, 2010, Vorstellung DWA M212 „Technische Ausrüstung von Faulgasanlagen auf Kläranlagen“  
In: DWA Veranstaltung Energietage

# Special parts

## Blower 特殊部分 鼓风机



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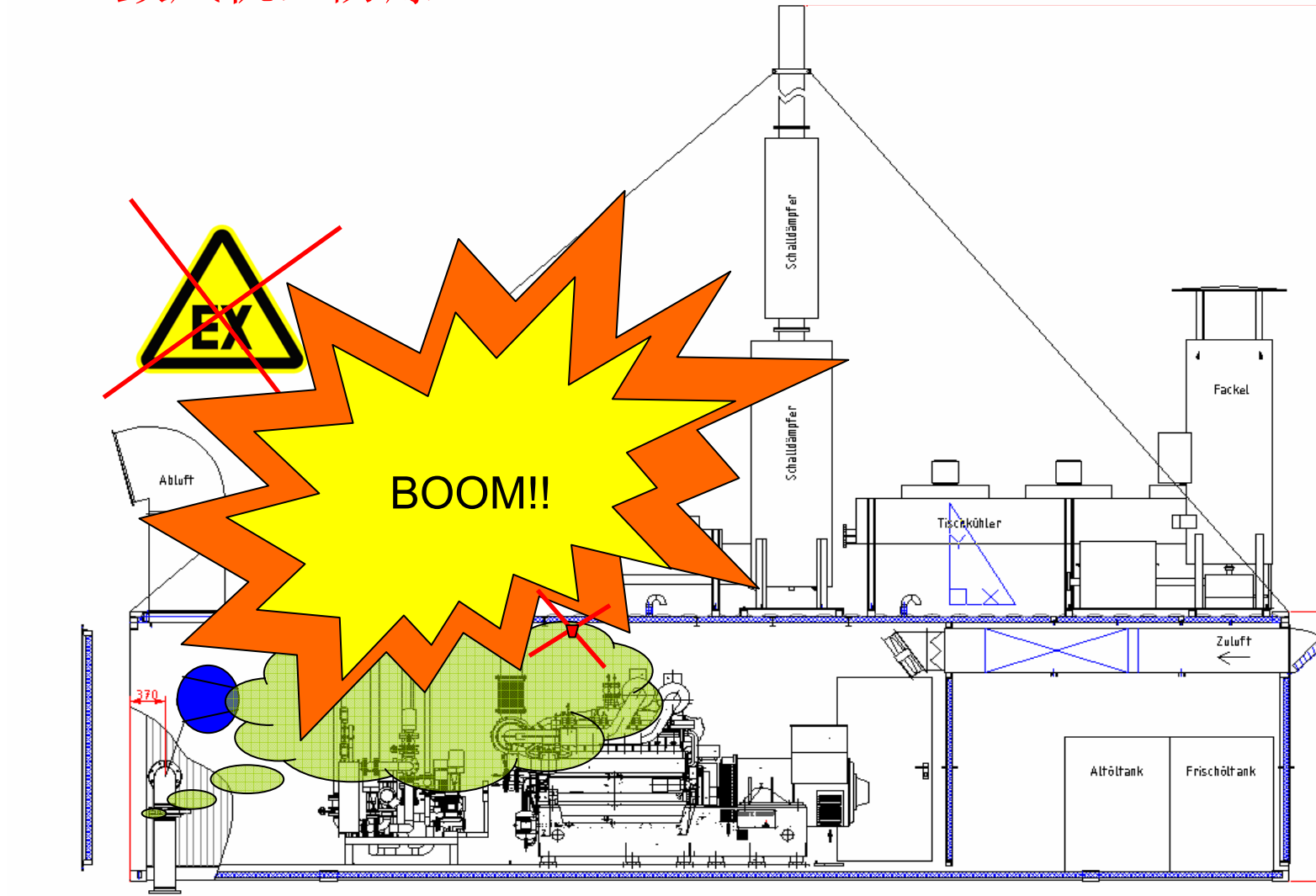
Special parts

Blower, explosion protection 特殊部分:

鼓风机, 防爆



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## Special parts

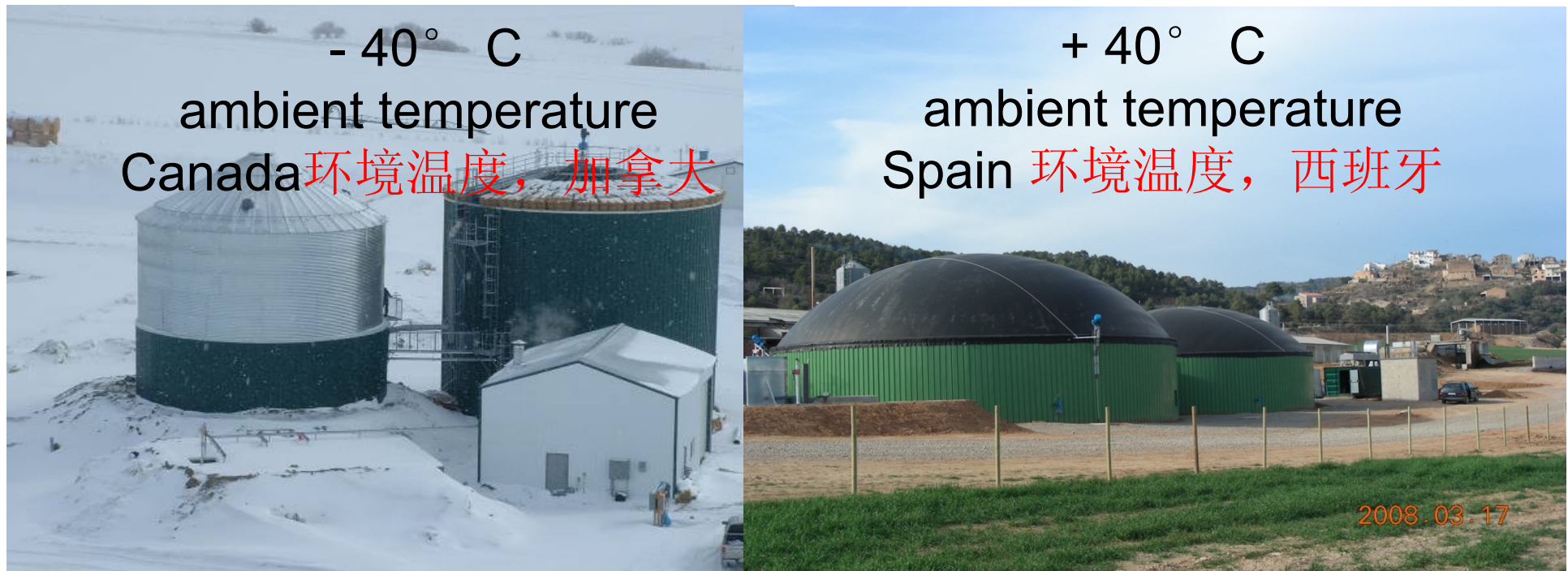
### Air input output 特殊部分：气体输入输出



- Supply with combustion air 空气的输送
- Cooling of the radiation of the engine 发动机降温
- High ambient temperature may become a problem  
Regarding DIN the lay out design of the table cooler base on a temperature of 25° C .  
高的环境温度可能成为一个问题，参考德国DIN中的标准，冷却器的布局设计是基于25°C的温度
- Standard rating of the engines:  
altitude ≤ 300-500 m  
发动机的规范化评级：海拔 ≤ 300-500m
- Starting system 0 – 60° C 启动系统0-60°C

Special parts  
Air input output

特殊部分：空气的输入输出



The local conditions are most important for the lay out design of the engine!

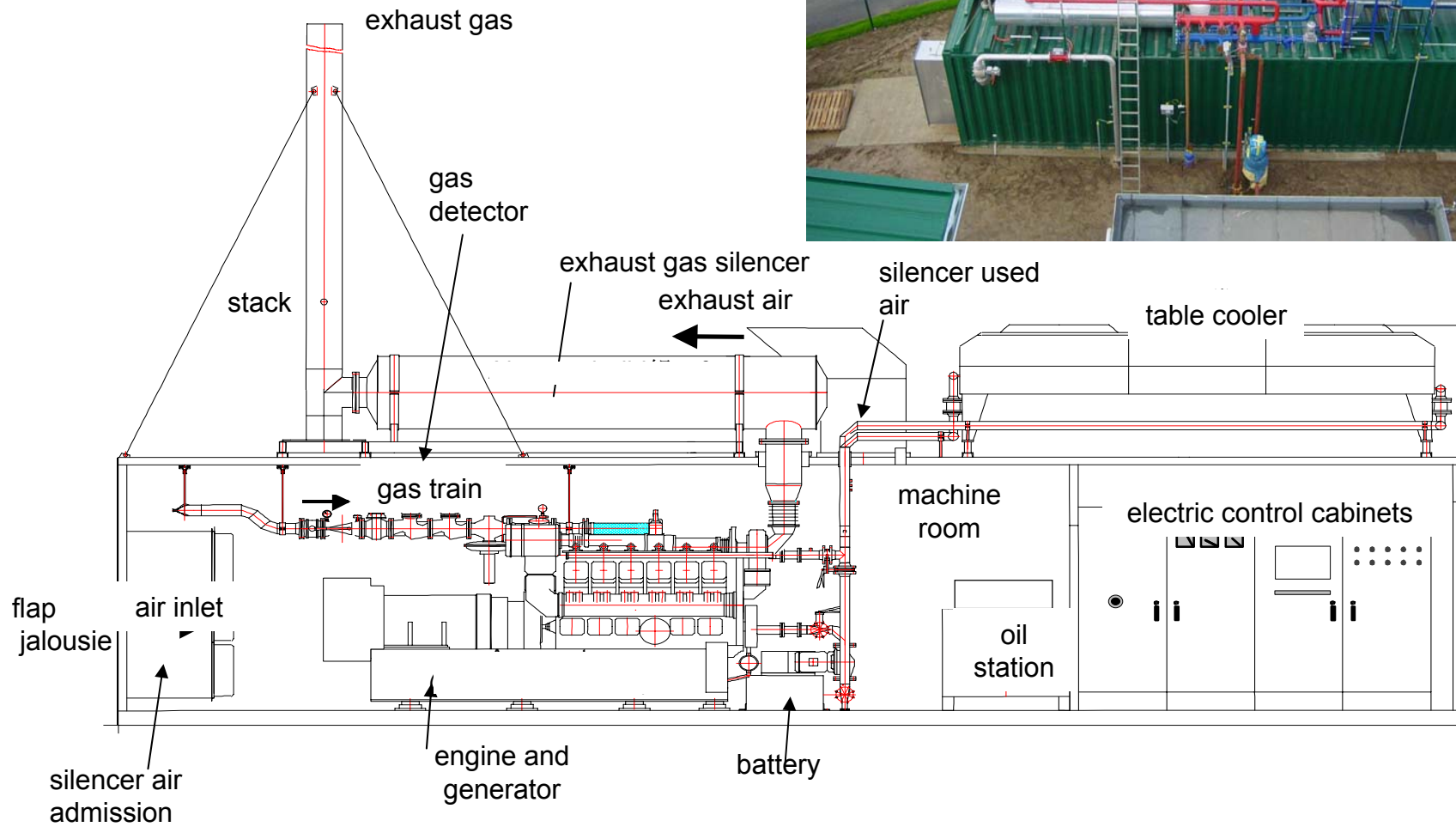
当地的条件是影响发动机的布局设计最重要的因素

**In China: different lay out design in Harbin or Hainan**

在中国：不同的布局设计在哈尔滨或海南

# Special parts Air input output

特殊部分：空气的输入和输出



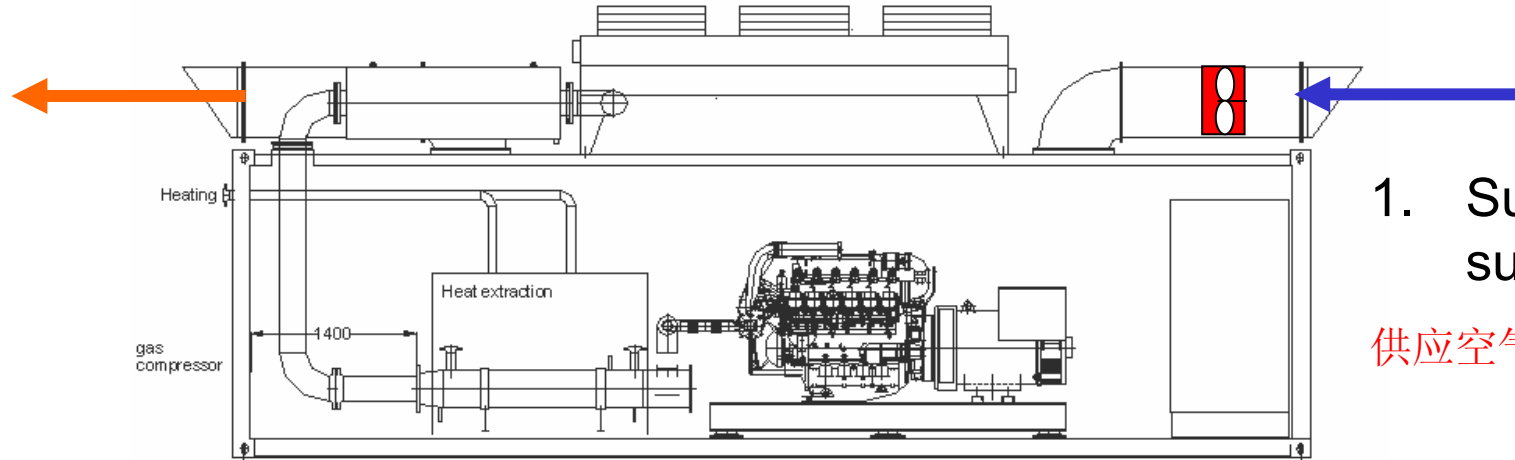


# Special parts

## Air input output 特殊部分：空气的输入和输出

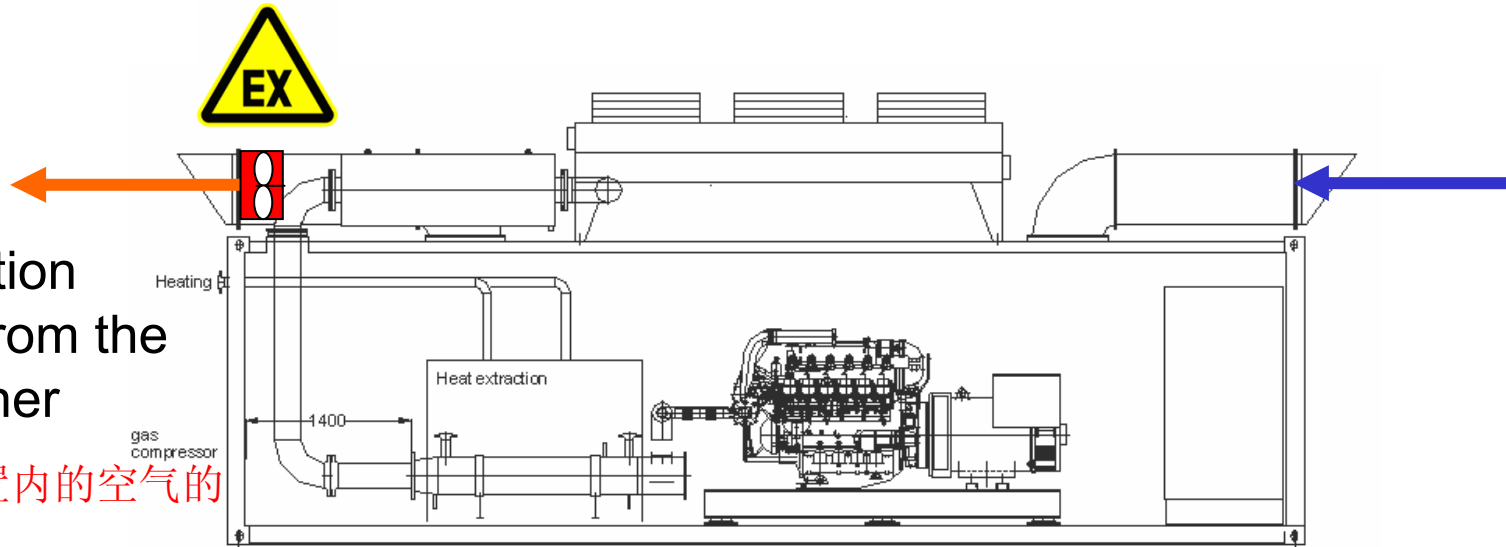


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1. Suction of supply air

供应空气的抽吸



2. Suction of air from the container

来至装置内的空气的抽吸

Special parts

Air input output 特殊部分: 空气的输入和输出



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Supply air  
with air filter

带有空气过滤器的供应空气



Hotteln

霍特尔恩

Exhaust air  
排气

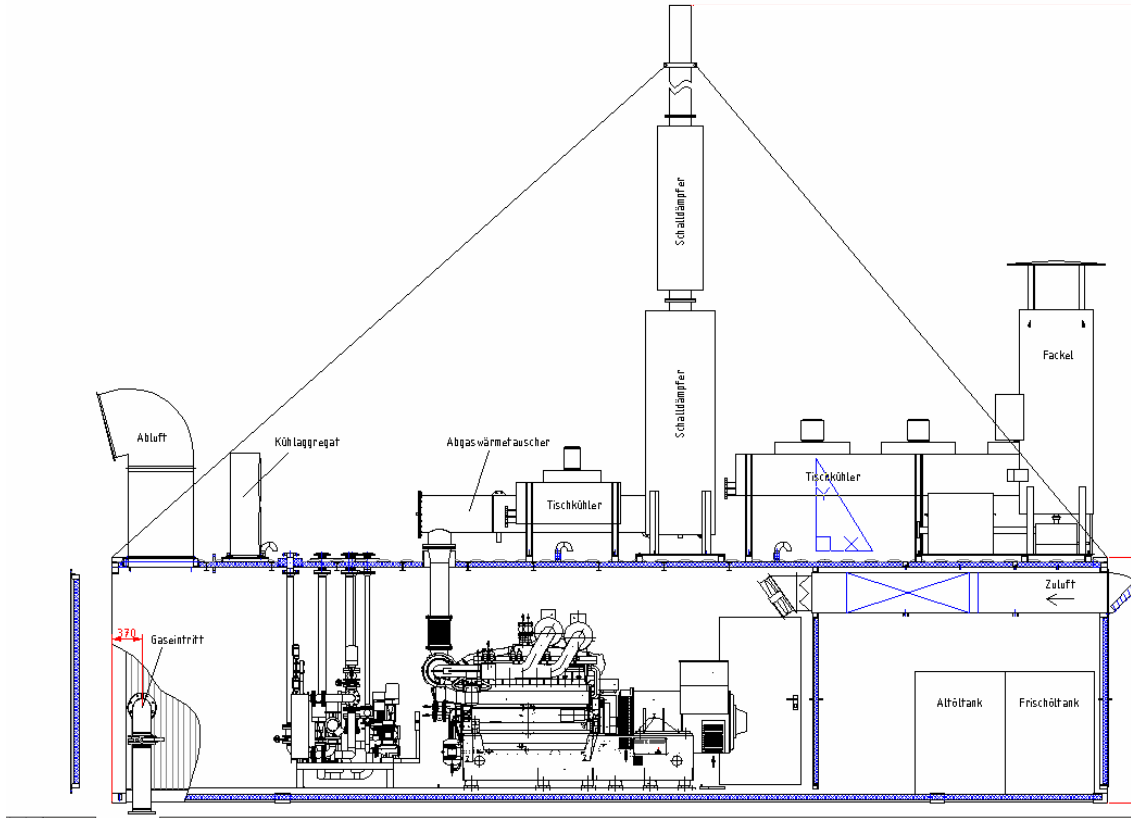


# Special parts

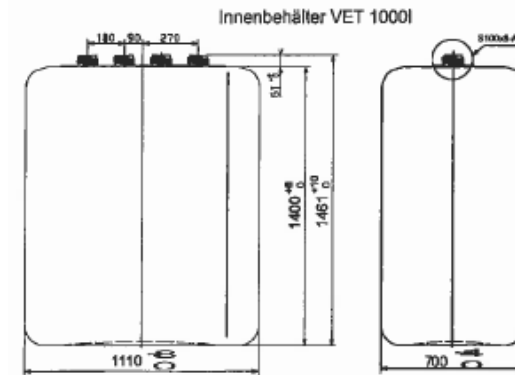
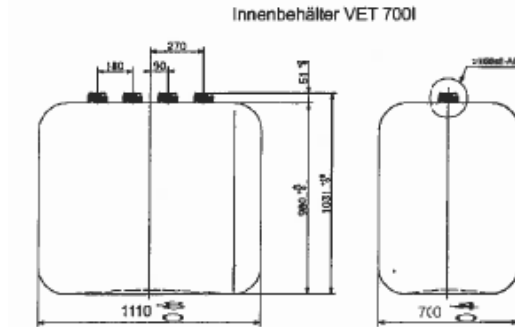
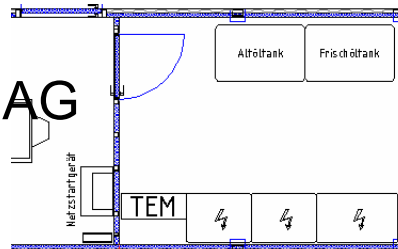
## Lubrication oil tanks 特殊部分：润滑油箱



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Source: SEVA Energie AG



Material: PE-HD



# Special parts

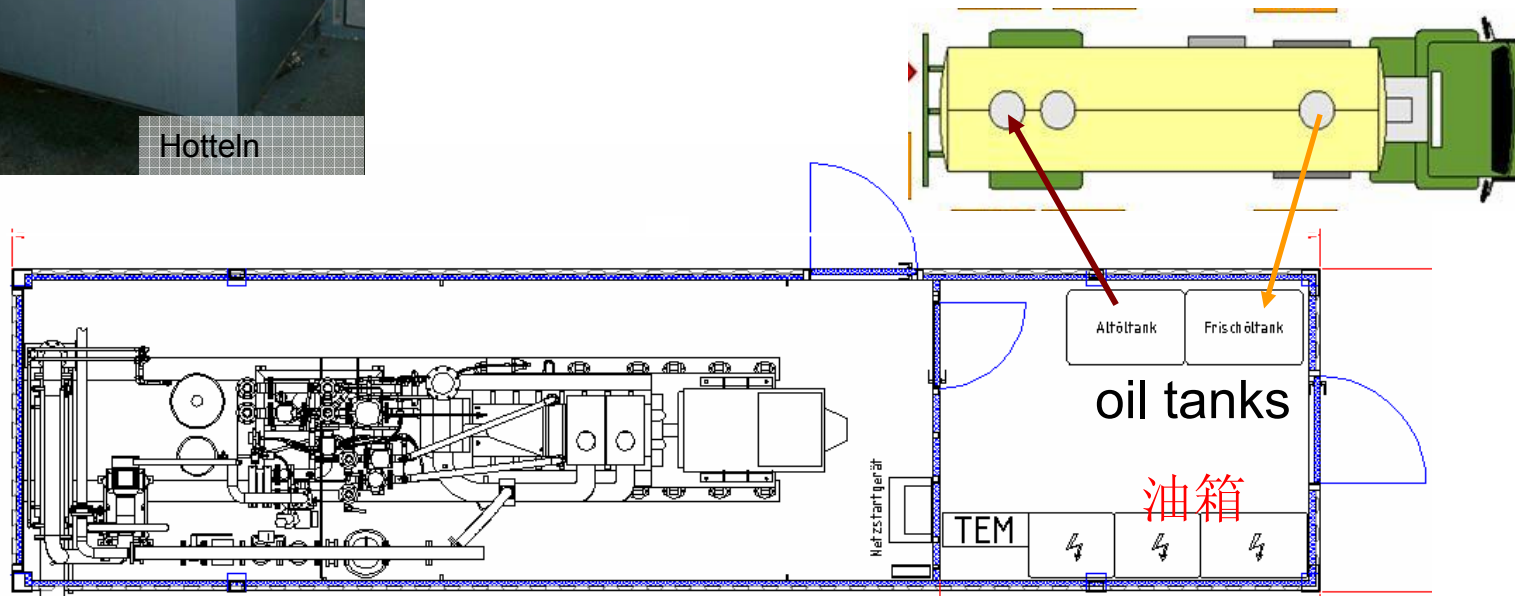
## Lubrication oil tanks 特殊部分：润滑油箱



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VAwS



Special parts

Heat utilisation 特殊部分：热能利用



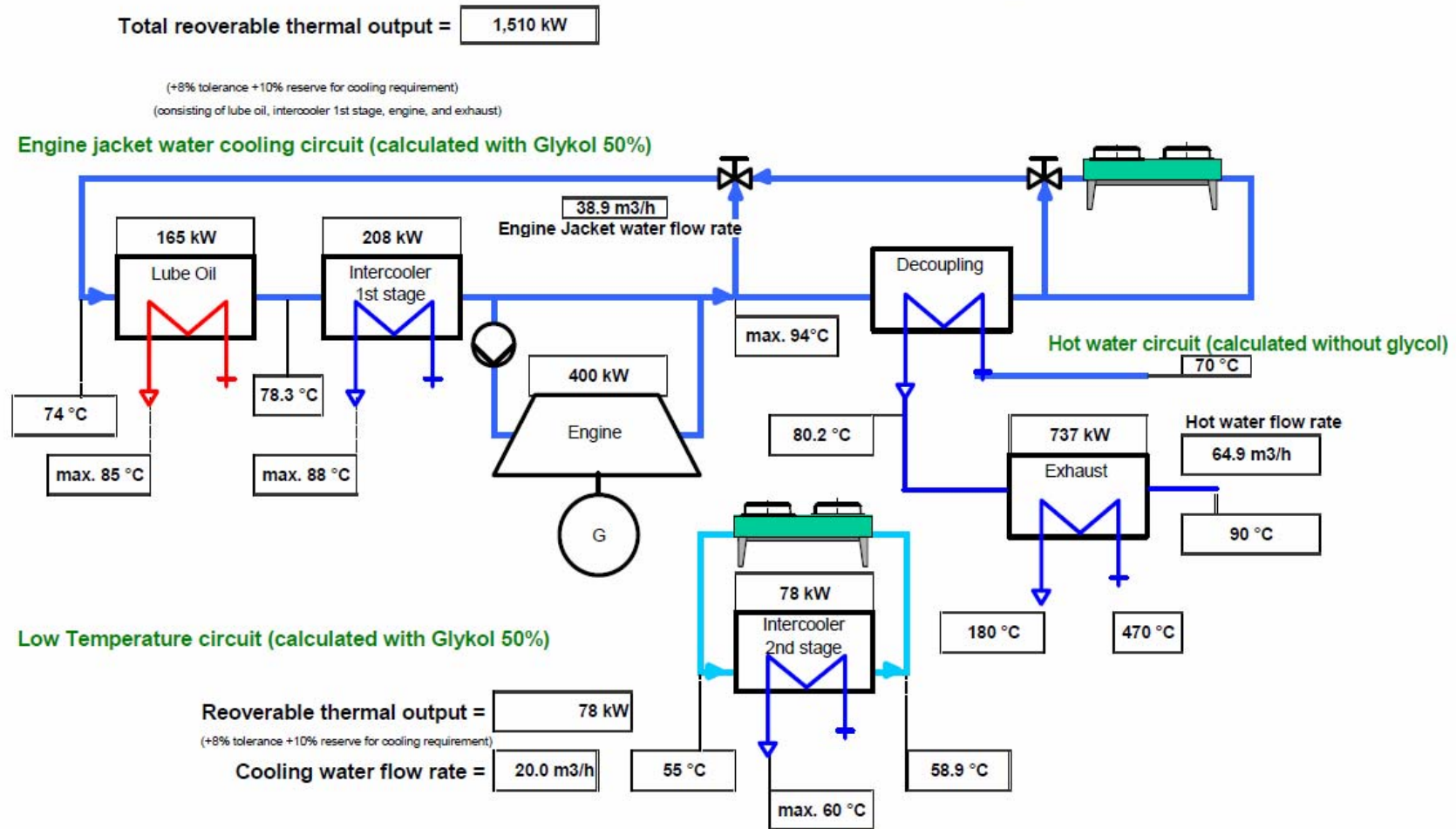
- Intercooler 中冷器  
→ heat has to be used or discharged in an emergency cooler 热量必须在一个紧急冷却器内被利用或释放
- Exhaust gas heat exchanger 废气热交换器  
→ optional, if heat can be used 可选择，如果热量可以被利用

# Special parts

## Heat utilisation 特殊部分：热能利用

Stormfisher Biogas

J 420 GS-A81





## Special parts

## Heat utilisation 特殊部分：热能利用



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- Domestic or industrial heating purposes

家庭或工业取暖

→ heat distribution grid

热量分配网

- Water heating 水加热
- Steam production 蒸汽产生
- Air conditioning, cold production with heat 空调，热冷采
- Drying (wood, wood-chips, grain...) 烘干（木材、木片、粮食）
- Thermal energy storage in a heat storage tank or thermo-chemical storage 在热储存器内或热化学储存来储存热能

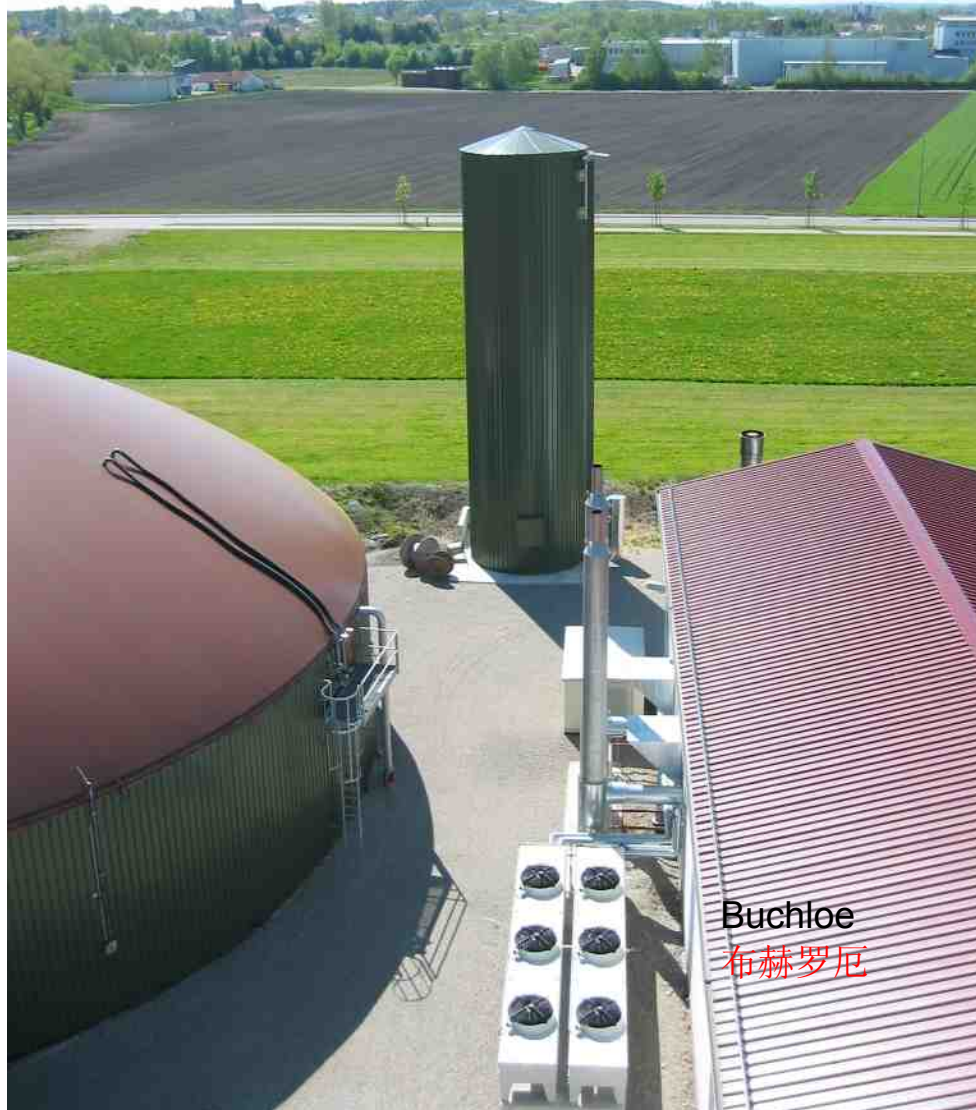


Special parts

Heat utilisation 特殊部分：热能利用



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Buchloe  
布赫罗厄



Heat storage tank 热能储存器

Special parts

Control 特殊部分：控制



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switch cabinet 开关柜

## Combined Heat and Power Plant 热电联产工厂



- Introduction CHP 热电联产介绍
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  - heat utilization 热能利用
  - Control 控制
- **Noise emission** 噪音
- Start-up 启动
- Maintenance, spare parts, maintenance contract 维修、备件、维修合同
- Mode of operation 操作模式
- Different types of CHP 不同类型的热电联产



## Noise emission 噪音排放

- Stack 烟囱
- Emergency cooler 紧急冷却器
- Air input output 空气的输入输出

TA Lärm (technical instruction on noise control)

The point of noise measurement is at the window of the nearest building.

噪音控制的技术指导：噪音的测量点是在最近的建筑物的窗户处

# Combined Heat and Power Plant



- Introduction CHP 热电联产介绍
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- Noise emission 噪音
- **Start-up** 启动
- Maintenance, spare parts, maintenance contract 维修、备件、维修合同
- Mode of operation 操作模式
- Different types of CHP 不同类型的热电联产

## Start-up 启动

### Commissioning 调试

- Proof full electric power with 50% CH<sub>4</sub>  
含甲烷50%情况下电能的充分论证
- Proof full thermal power with 50% CH<sub>4</sub>  
含甲烷50%情况下热能的充分论证
- Proof noise emission 噪音论证
- Proof exhaust gas emission 废气排放论证
- Commissioning regarding safety 安全方面的调试

# Combined Heat and Power Plant



- Introduction CHP 热电联产介绍
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- Noise emission 噪音
- Start-up 启动
- **Maintenance, spare parts, maintenance contract** 维修、备件、维修合同
- Mode of operation 操作模式
- Different types of CHP 不同类型的热电联产

## CHP Maintenance 热电联产系统的维修

- Maintenance service 维修服务
- Spare parts, spare parts procurement 备件, 备件采购
- Service contract 服务合同

Pro2 – maintenance plan for motorplants type 620

Maintenance  
plan CHP

热电联产系统的维  
修计划

Description of activities	E1	E2	E3	E4	E5	E6	E7
<b>1. management by operator/client</b>							
Visual check of the total plant (daily)							
Check display instruments (daily)							
Check vibrations (daily)							
Check running noise (daily)							
Check reattachments (daily)							
Check impermeability (daily)							
Keep of the operating journal (if necessary)							
Trouble shooting after co-ordination with Pro2 (if necessary)							
Message to Pro2 after operation disturbance (if necessary)							
Message to pro2 after operational abnormalities (if necessary)							
Transfer journal to Pro2 (if necessary)							
Receipt goods (oil, spare parts) (if necessary)							
Check lube oil level and refill oil if necessary/(daily)							
<b>2. IC gas-engine</b>							
Visual check of the total plant	X	X	X	X	X	X	X
Test an function run	X		X	X	X	X	X
Checking the lube oil level	X	X	X	X	X	X	X
Checking the coolant level	X	X	X	X	X	X	X
Leak check on engine, lines and engine drain	X	X	X	X	X	X	X
Checking the engines for vibrations and running noises	X	X	X	X	X	X	X
External visual inspection	X	X	X	X	X	X	X
Checking the valve clearance	X		X	X	X	X	X
Checking the starter battery	X		X	X	X	X	X
Checking the spark plugs			X	X	X	X	X
Checking the engine venting feature					X	X	X
Changing the lube oil filter	X			X	X	X	X
Checking and record operational data and performance characteristics	X	X	X	X	X	X	X
Replacing the air filter inserts, cleaning the air filter housing					X	X	X
Checking ignition timing					X	X	X
Checking the governor			X	X	X	X	X

bH

## Pro2 – maintenance plan for motorplants type 620

Description of activities	E1	E2	E3	E4	E5	E6	E7
<b>1. management by operator/client</b>							
Visual check of the total plant <b>(daily)</b>							
Check display instruments <b>(daily)</b>							
Check vibrations <b>(daily)</b>							
Check running noise <b>(daily)</b>							
Check reattachments <b>(daily)</b>							
Check impermeability <b>(daily)</b>							
Keep of the operating journal <b>(if necessary)</b>							
Trouble shooting after co-ordination with Pro2 <b>(if necessary)</b>							
Message to Pro2 after operation disturbance <b>(if necessary)</b>							
Message to pro2 after operational abnormalities <b>(if necessary)</b>							
Transfer journal to Pro2 <b>(if necessary)</b>							
Receipt goods (oil, spare parts) <b>(if necessary)</b>							
Check lube oil level and refill oil if necessary/ <b>(daily)</b>							

<b>2 IC gas-engine</b>	<b>E1</b>	<b>E2</b>	<b>E3</b>	<b>E4</b>	<b>E5</b>	<b>E6</b>	<b>E7</b>
Visual check of the total plant	X	X	X	X	X	X	X
Test an function run	X		X	X	X	X	X
Checking the lube oil level	X	X	X	X	X	X	X
Checking the coolant level	X	X	X	X	X	X	X
Leak check on engine, lines and engine drain	X	X	X	X	X	X	X
Checking the engines for vibrations and running noises	X	X	X	X	X	X	X
External visual inspection	X	X	X	X	X	X	X
Checking the valve clearance	X		X	X	X	X	X
Checking the starter battery	X		X	X	X	X	X
Checking the spark plugs			X	X	X	X	X
Checking the engine venting feature					X	X	X
Changing the lube oil filter	X			X	X	X	X
Checking and record operational data and performance characteristics	X	X	X	X	X	X	X
Replacing the air filter inserts, cleaning the air filter housing					X	X	X
Checking ignition timing					X	X	X
Checking the governor			X	X	X	X	X





Description of activities	E1	E2	E3	E4	E5	E6	E7
Checking crank case pressure			X	X	X	X	X
Checking, cleaning and adjusting gas-mixer-system			X	X	X	X	X
Checking the pick up (ignition, rpm, electronic controller)					X	X	X
Checking the engine mount					X	X	X
Checking the starter and ring gear					X	X	X
Checking, cleaning the coolant and exhaust gas heat exchangers					X	X	X
Replacing cylinderheads					X	X	X
Cleaning the combustion compartments, checking the cylinder liners					X		
Replacing cylinder liners						X	X
Checking and cleaning the coolant controller					X	X	X
Replacing the coolant hoses and pipe connectors					X	X	X
Cleaning the lube oil cooler						X	X
Checking and cleaning the intercooler						X	X
Checking and cleaning the cooling pump						X	X
Checking the valve mechanism						X	X
Replacing the conn. rod bearings,						X	X
Pleuelbuchsen prüfen, ggf. erneuern replacing if necessary						X	X
Checking fittings and regulators						X	X
Replacing pistons						X	X
Replacing piston rings						X	X
Checking the engine alignment and coupling							X
Measuring the crankshaft							X
Replacing the main bearing							X
Replacing the crankshaft sealing rings							X
Checking and cleaning geartrain and control system							X
Checking camshaft, replacing if necessary							X
Replacing camshaft bearing							X
Replacing lubeoil pump							X
Cleaning, checking the oil pressure holding valve							X
Checking and cleaning the turbocharger	<b>Regard manufacturers operating instructions, regard documentation,</b>						

<b>Description of activities</b>	<b>E1</b>	<b>E2</b>	<b>E3</b>	<b>E4</b>	<b>E5</b>	<b>E6</b>	<b>E7</b>
Checking crank case pressure			X	X	X	X	X
Checking, cleaning and adjusting gas-mixer-system			X	X	X	X	X
Checking the pick up (ignition, rpm, electronic controller)					X	X	X
Checking the engine mount					X	X	X
Checking the starter and ring gear					X	X	X
Checking, cleaning the coolant and exhaust gas heat exchangers					X	X	X
Replacing cylinderheads					X	X	X
Cleaning the combustion compartments, checking the cylinder liners					X		
Replacing cylinder liners						X	X
Checking and cleaning the coolant controller					X	X	X
Replacing the coolant hoses and pipe connectors					X	X	X
Cleaning the lube oil cooler						X	X
Checking and cleaning the intercooler						X	X
Checking and cleaning the cooling pump						X	X
Checking the valve mechanism						X	X

	E1	E2	E3	E4	E5	E6	E7
Replacing the conn. rod bearings,						X	X
Pleuelbuchsen prüfen, ggf. erneuern replacing if necessary						X	X
Checking fittings and regulators						X	X
Replacing pistons						X	X
Replacing piston rings						X	X
Checking the engine alignment and coupling							X
Measuring the crankshaft							X
Replacing the main bearing							X
Replacing the crankshaft sealing rings							X
Checking and cleaning geartrain and control system							X
Checking camshaft, replacing if necessary							X
Replacing camshaft bearing							X
Replacing lubeoil pump							X
Cleaning, checking the oil pressure holding valve							X
Checking an cleaning the turbocharger	<b>Regard manufacturers operating instructions, regard documentation,</b>						

Description of activities	E1	E2	E3	E4	E5	E6	E7
<b>3. Generator</b>							
Check cable conetions					X	X	X
Lubrication of the generator bearings	<b>Regard manufacturers operating Instructions, regard documentation</b>						
Adjust Cos.-Phi-Regelung controler				X			X
Adjust voltage controller				X			X
<b>4. Gasleitungssystem</b>							
Complete leak check				X			X
Adjust gas-mixer-system				X			X
Adjust zero-pressure-controller				X			X
Check the shut-off valves				X			X
Changing gasfilter	X			X			X
Check gas-pressure-monitoring				X			X
Clean deflagration-protection-system				X			X



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Information Maintenance plan:

Intervals at/after	Maintenance stages	Execution
50 Oh (operating hours)	E1 After commissioning and E5, E6, E7	Authorized trained stuff
Daily	E2 Daily check routine	Operator
1,500 Oh	E3 Inspection	Authorized trained stuff
3,000 Oh	E4 Extended inspection	Authorized trained stuff
12,000 Oh	E5 Intermediate overhaul	Authorized trained stuff
24,000 Oh	E6 Extended intermediate overhaul	Authorized trained stuff
48,000 Oh	E7 Major overhaul	Authorized trained stuff

Details of the Maintenance plan:

Approx. 50 working hours after first commissioning resp. recommissioning an oil change is necessary. Subsequently the oil have be to changed at the given interval.

The given periods are average values for normal operating conditions and approved maintenance. These are standard values without guarantee commitments. If there are stronger conditions it can be necessary that the maintenance interval must be shorter. Stronger conditions are caused by frequently starts, long working hours at low power level, extremely fast and frequently load alternation and frequently work with overload and bad gas quality.

Under special conditions (part load operation) the maintenance interval can be longer.



Description of activities	E1	E2	E3	E4	E5	E6	E7
<b>3. Generator</b>							
Check cable conetions					X	X	X
Lubrication of the generator bearings	<b>Regard manufacturers operating Instructions, regard documentation</b>						
Adjust Cos.-Phi-Regelung controler				X			X
Adjust voltage controler				X			X
<b>4. Gasleitungssystem</b>							
Complete leak check				X			X
Adjust gas-mixer-system				X			X
Adjust zero-pressure-controller				X			X
Check the shut-off valves				X			X
Changing gasfilter	X			X			X
Check gas-pressure-monitoring				X			X
Clean deflagration-protection-system				X			X

Information Maintenance plan:

Intervals at/after	Maintenance stages		Execution
50 Oh (operating hours)	E 1	After commissioning and E 5, E 6, E 7	Authorized trained staff
Daily	E 2	Daily check routine	Operator
1,500 Oh	E 3	Inspection	Authorized trained staff
3,000 Oh	E 4	Extended inspection	Authorized trained staff
12,000 Oh	E 5	Intermediate overhaul	Authorized trained staff
24,000 Oh	E 6	Extended intermediate overhaul	Authorized trained staff
48,000 Oh	E 7	Major overhaul	Authorized trained staff

bH

Details of the Maintenance plan:

Approx. 50 working hours after first commissioning resp. recommissioning an oil change is necessary. Subsequently the oil have be to changed at the given interval.

The given periods are average values for normal operating conditions and approved maintenance. These are standard values without guarantee commitments. If there are stronger conditions it can be necessary that the maintenance interval must be shorter. Stronger conditions are caused by frequently starts, long working hours at low power level, extremely fast and frequently load alternation and frequently work with overload and bad gas quality.

Under special conditions (part load operation) the maintenance interval can be longer.

# Maintenance

## General maintenance 维修 一般性维修



## Oil change 换油

periodically analysis of the oil (pH-value, sulfur)

定期油品分析 (pH、S含量)

The interval of oil change depends on

→ the concentration of sulfur in the gas / oil

→ the buffer capacity of the inserted oil

→ others

换油间隔时间取决于:

在气体/油中S的浓度;

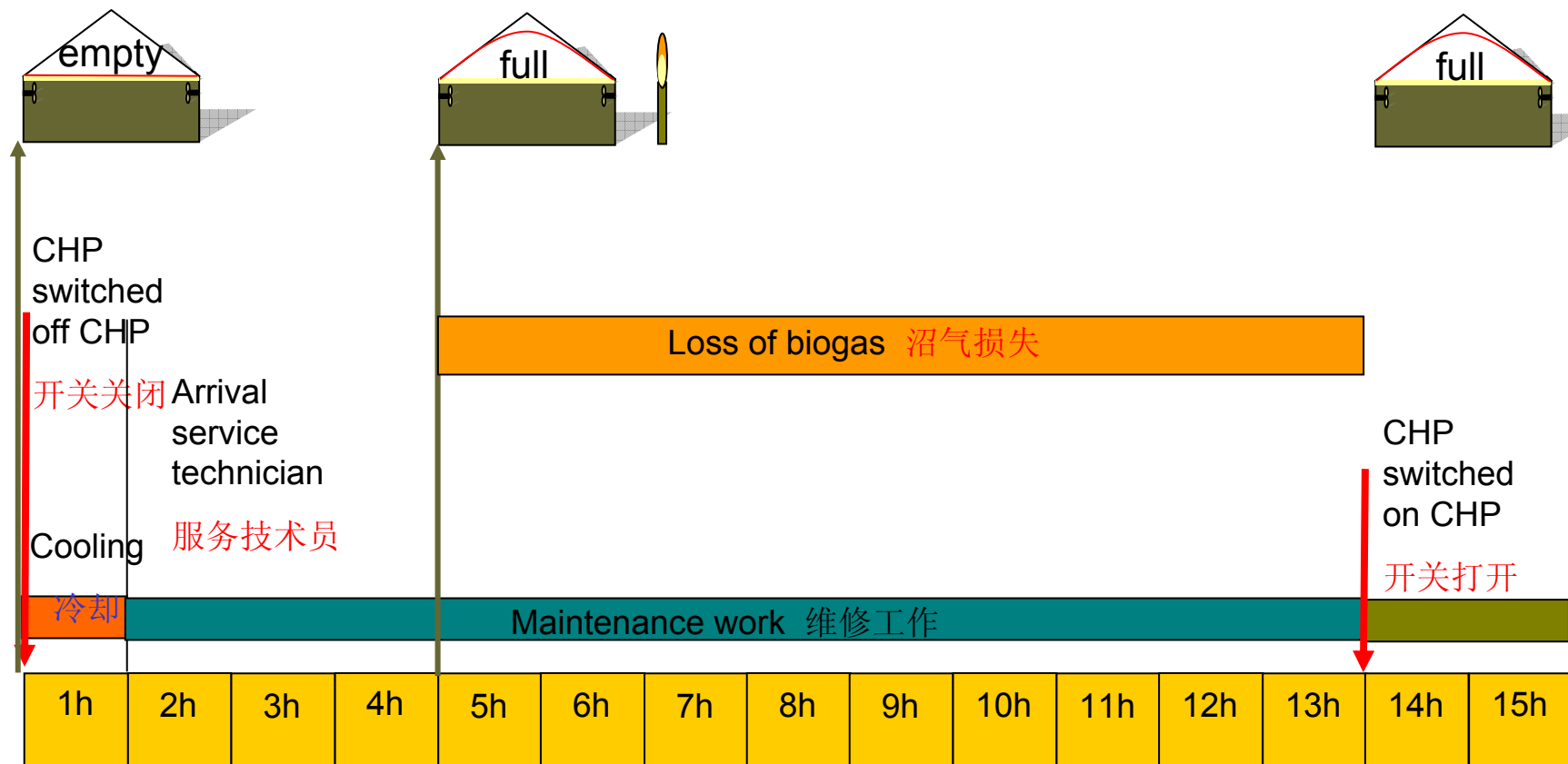
内置油的缓冲能力;

其他

Every operator has to determine the necessary interval of oil change of his engine by himself!

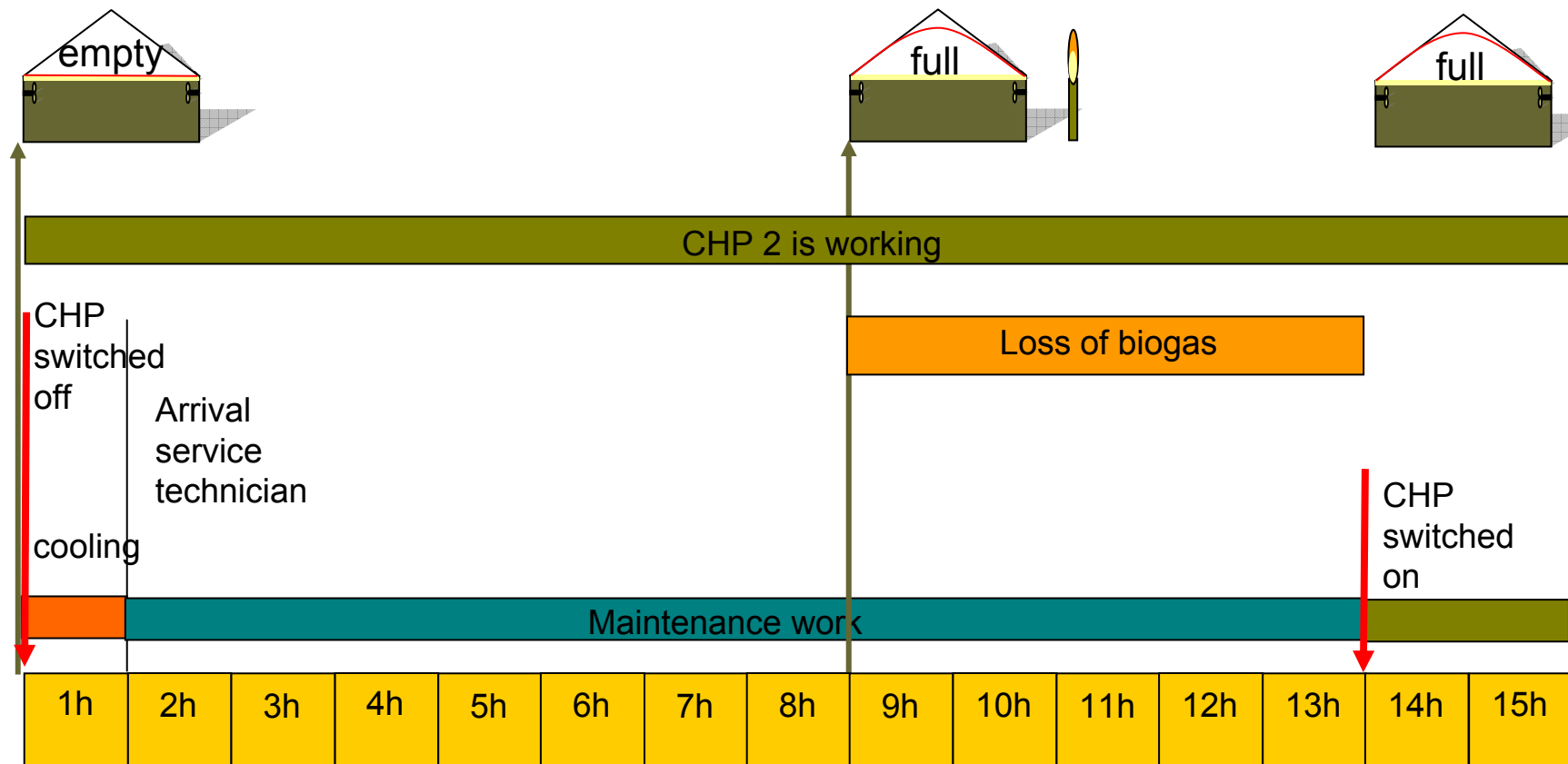
每个操作者必须自己决定自己负责的发动机换油的间隔时间!

# Maintenance cylinder head 1 engine (1 MW<sub>e</sub>) 维修缸盖



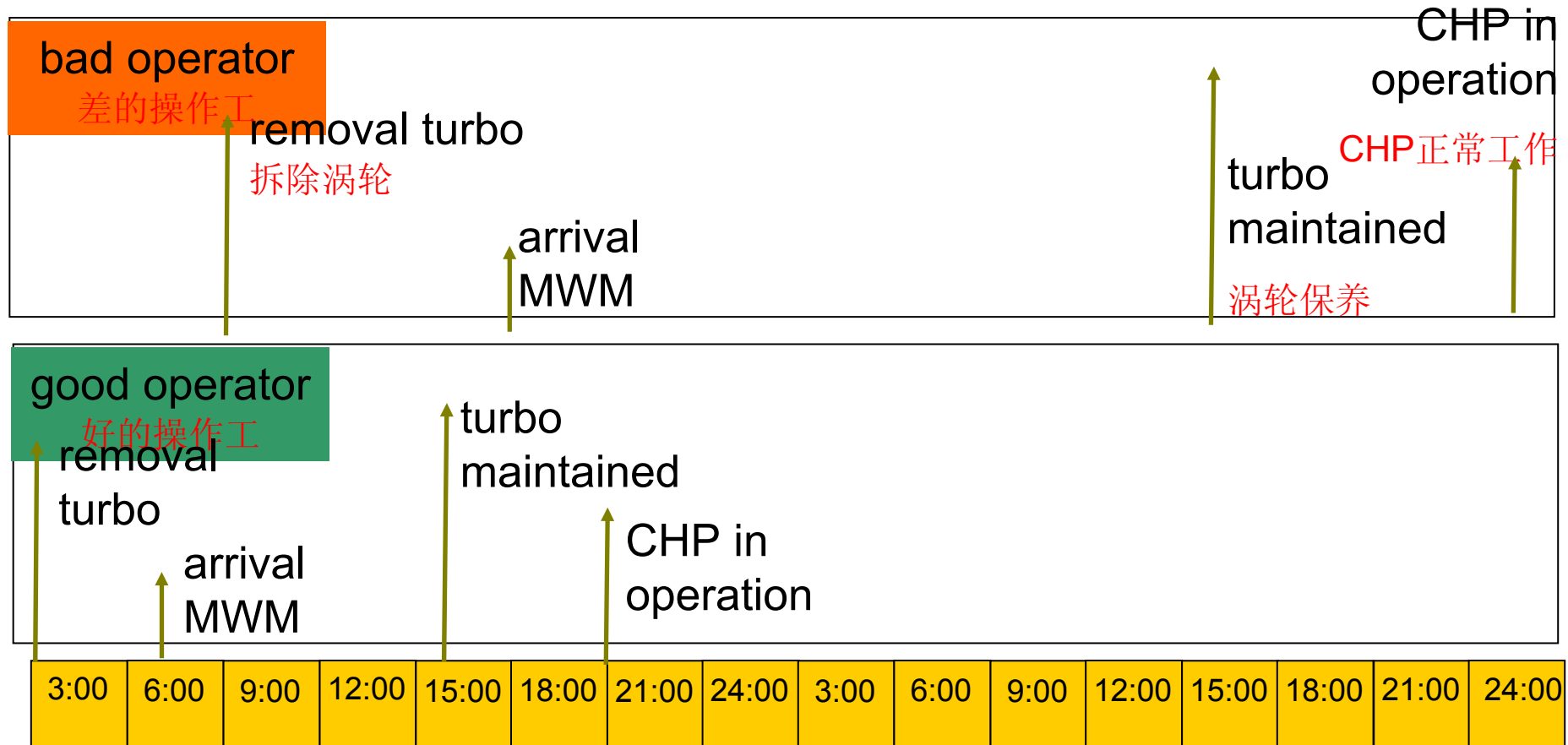


# Maintenance cylinder head 2 engines (500 kW<sub>e</sub> each) 维修缸盖



# Maintenance

## Turbo 维修涡轮



- Introduction CHP 热电联产介绍
- Safety 安全性
- Container / Building 装置/建筑物
- Pretreatment of biogas / Exhaust gas emission 沼气预处理/废气排放
- Special parts 特殊部分
  - Blower 鼓风机
  - air input output 空气的输入输出
  - lubrication oil tanks 润滑油箱
  - heat utilization 热能利用
  - Control 控制
- Noise emission 噪音
- Start-up 启动
- Maintenance, spare parts, maintenance contract 维修、备件、维修合同
- **Mode of operation** 操作模式
- Different types of CHP 不同类型的热电联产

## Mode of operation 操作模式

- Stand alone operation  
The gas engine is not connected to the electric grid  
单独运作  
气体发动机未与电网相连
- Parallel to grid operation  
The electricity produced in cogeneration is fed to the electric grid  
与电网并行运行  
热电联产中产生的电供给电网

# Combined Heat and Power Plant



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## Different types of CHP 不同类型的热电联产

- Gas-otto-engine  
(80% of all engines in Germany)  
天然气-汽车-发动机 (占德国发动机的80%)
- Dual fuel engine  
(20%,  $\leq 350$  kW)  
双燃料发动机(20%,  $\leq 350$  kW)



# Comparison

## Gas-Otto engine – dual fuel engine

### 对比 气体 - 汽车 - 双燃料发动机



	Gas-Otto engine	Duel fuel engine
	otto engine 汽车发动机	diesel engine 柴油机
	Possibility to be fueled by biogas or natural gas only (-) 仅可能利用沼气或天然气	Possibility to be fueled by heating oil / bio diesel (+) or gas 可能利用取暖油/生物柴油或气体
	No other fuel necessary (+) 不需要其它燃料	max. 10% heating oil (2% modern engines) necessary (-) 需要最大10%的取暖油
	overall efficiency higher 整体效率高	overall efficiency lower 整体效率低
	Lower electrical efficiency (<40%) 电效率低 (<40%)	Higher electrical efficiency (44%) 电效率高 (44%)
	durability about 60.000 operating hours (+) 耐久性约6万个工作小时	durability about 35.000 operating hours (-) 耐久性约3.5万个工作小时
	Bigger engines 100 – 1000 kW 较大型发动机	small engines < 250 kW 小型发动机
	at least 45 % CH4 至少45%甲烷	low gas quality is no problem 气体质量低是没有问题的

International best practice  
Middle-Large Scale Biogas-Plant-technology  
Planning and Design II  
Design of CHP modules

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