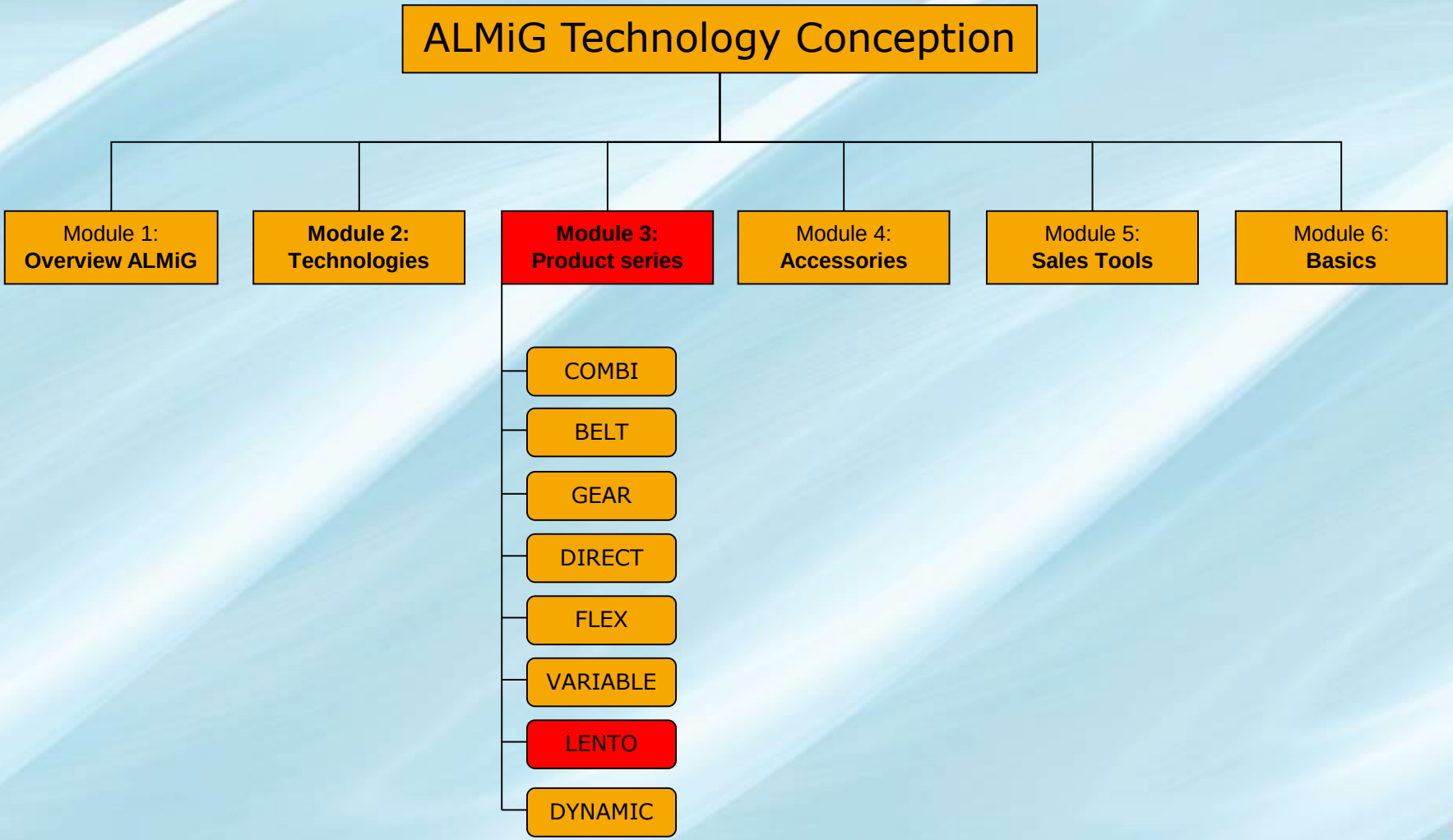
Product series: LENTO



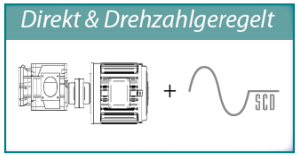
The LENTO series:

100 % oil-free compressed air by means of “water injection technology!”

- LENTO - Overview
- Applications / References
- The LENTO technology in detail
- TOP reasons

The LENTO series - Overview

Facts

Application:	100% oil-free compressed air for industry (pharmaceuticals, food, chemicals etc.)
Output:	LENTO I: 15 – 30 KW LENTO II: 30 – 55 KW LENTO III: 45 – 80 KW LENTO IV: 80 – 110 kW
Operating pressure:	LENTO I & II: 5 - 10 bars LENTO III & IV: 5 – 13 bars
Control unit:	Air Control 3
Cooling system:	Water-cooled: (Standard) Air-cooled: (option) from LENTO 80 water-cooled only
Drive:	

Applications & References

It is not only in the fields of pharmaceuticals, food, electrical engineering and medicine that 100 % oil-free compressed air is required; it also applies wherever top quality products are manufactured.

Example: Medical technology
For example the production of droppers and plastic measuring cuvettes under cleanroom conditions

Example: Cosmetics
The manufacture of cosmetics. Compressed air comes into contact with the product and therefore has to be absolutely "clean"- Almost the same rules apply to it as for the pharmaceuticals industry

Example: Food technology
"Cleanliness" has top priority for the production of food - and that also applies to the compressed air!

Example: Solar panels and PCB
In the very diverse field of "micro electronics" the production conditions have to meet extremely high requirements.

Applications & References

A selection of companies which rely on
100 % oil-free compressed air from ALMiG:

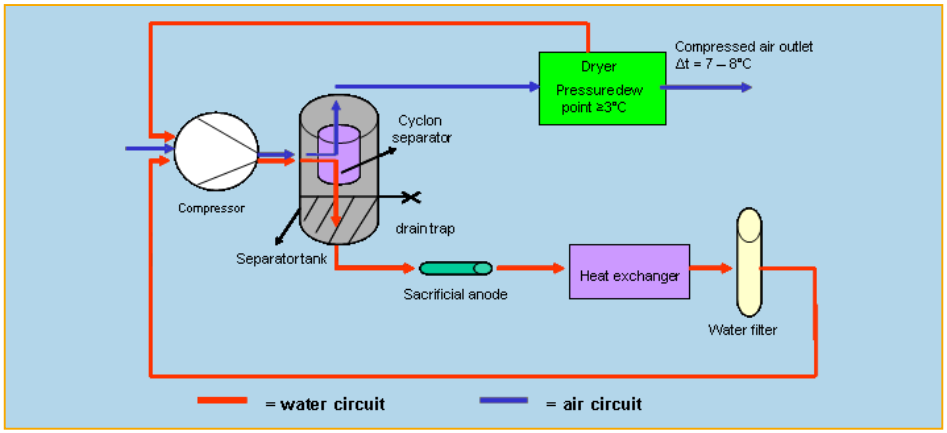
References	
Customer	**Application**
Romina Mineralbrunnen	Beverage industry
Riemser Pharma	Pharmaceuticals industry
Jenoptik	Solar panel + PCB manufacturers
Schwan Stabilo Cosmetics	Cosmetics manufacturers
Uniklinikum Essen	Hospital
Fraunhofer Institute	Research & Development
Global Light Industries	Nanotechnology
Plantextrakt	Food
Leuna Epilox GmbH	Chemicals industry
AREVA	Nuclear technology
Salutas / Sandoz Pharma	Pharmaceuticals industry
Kölner Hofbräu	Brewery
Kulmbacher	Brewery
EPS Electronics	Electrotronics manufacturers

LENTO 15 - 55

The LENTO series: Component layout

Airend	1	single-stage, water-injected • the housing made from stainless alloy encompasses the two rotors for economical compression (male and female rotors) • minimal final compression temperatures below 60°C (hence close to the isotherm - i.e. economically efficient compression)
SCD motor	2	highly efficient drive motor • IP 55 protection class ISO H • compact, powerful and reliable in operation
Integrated refrigerant dryer	3	with triple tasking: produces fresh water for the permanent generation and circulation of the coolant required • for optimum biological and chemical water quality • provides dry compressed air on entering the compressed air network
Water circuit	4	closed water circuit with independent, integrated water treatment • multi-stage separation for dry compressed air
SCD direct drive	5	loss-free power transmission, optimal cost savings
SCD frequency converter	6	the integrated power pack, conforms to EMC ordinances, of course
Air Control	7	the compressor's intelligence; thinks, monitors and records

The LENTO technology: Unique - Simple - Efficient



The water circuit:

1. Water is injected into the compressor airend and thereafter reaches the stainless steel separation receiver as an air / water mix
2. The cyclone separator separates water and compressed air (no build-up of pressure losses)
3. The separated water is supplied with minerals via a sacrificial anode
4. The water cools down in the heat exchanger
5. The water filter filters out suspended matter and the water re-enters the compressor airend by injection

Air circuit

1. Air is sucked into the compressor airend via the intake air filter and thereafter enters the stainless steel separation receiver as an air / water mix
2. The cyclone separator separates water and compressed air
3. The compressed air, 100% saturated with water, passes into the integrated refrigerant dryer
4. The compressed air is dried in the integrated refrigerant dryer. The pure water that then accumulates is returned to the process.
5. The 100% oil-free compressed air leaves the compressor dry and with a pressure dew point of ≥ 3° C

TOP 1: The integrated “water producer”

The integrated refrigerant dryer is an essential part of water treatment and serves primarily to produce fresh water

- Positive side effect:
  - “Automatic” dry compressed air
  - It is frequently possible to do without an external refrigerant dryer
  - Saves the operator investment costs
- Pressure dew points of ≥ 3° C at 100% capacity utilisation are given
  - In the case of the speed-controlled LENTO plants the pressure dew point improves at < 100% capacity utilisation
- The refrigerant dryer is controlled directly via the compressor
  - All the important parameters can be read off via AIR CONTROL 3

TOP 1: The integrated "water producer"

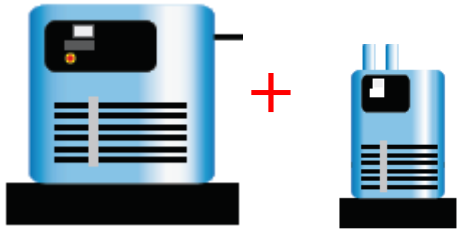
Important: The data for the refrigerant dryer

- Power consumption [kW]
- Pressure loss Δ p [bars]

are included in the LENTO performance data

➢ When comparing the spec. performance data with other systems, this must be taken into account

=



Example:
55 kW compressor "Stand alone dryer"
Power consumption = ~ 1.4 kW
Pressure loss = ~ 0.3 bars

1. The **1.4 kW** power consumption must be added on for other systems
2. 1 bar pressure = 7% higher power consumption
   => 0.3 bar pressure = 2.1% higher power consumption
   55 kW * 2.1% = + **1.2 k**W

2.6 kW must be taken into account!
~ 4.5% higher power consumption than is apparent at first glance!

TOP 2: Certified compressed air quality

Distinguished institutions confirm LENTO's high compressed air quality

- Test

"INSTITUT DR. APPELT"

INSTITUT DR. APPELT GmbH & Co. KG

The compressed air contains no copper !

INSTITUT DR. APPELT GmbH & Co. KG

Prüfbericht 07-12042

TOP 2: Certified compressed air qualit

Distinguished institutions confirm
LENTO's high compressed air quality

- Test

"TÜV Rheinland"

TÜVRheinland

No detectable oil in the compressed air purity class "0" !!

Compressed air quality classes comply with DIN ISO 8573-1

Class	Maximum number of particles / m³ Particle size d (µm) 0,1< d ≤ 0,5	0,5 < d ≤ 1	1 < d ≤ 5	Pressure dew point (°C)	Oil residue (mg/m³)
0	specified according to application and better than class 1				
1	100	1	0	≤ -70	0,01
2	100.000	1.000	10	≤ -40	0,1
3	–	10.000	500	≤ -20	1
4	–	–	1.000	≤ +3	5
5	–	–	20.000	≤ +7	–

The **LENTO** series is certified by TÜV
in conformity with **class 0** regarding their residual oil content

TOP 2: Certified compressed air quality

Distinguished institutions confirm
LENTO's high compressed air quality

- Test

"FRESENIUS Institute"

FRESENIUS

Germs and solid particles are signifi-
cantly reduced owing to the process!

INSTITUT
FRESENIUS

Summary
Our investigations on air quality with the compressor

LENTO 30

Oil Content

Based on the investigations done the oil concentration of the compressed air at the outlet is identical to the concentration of the induction air.

Particles

The concentration of particles in the compressed air is significantly reduced against the concentration in the induction air.

Microbiology

The microbial quantities based on colony forming units (CFU) in the compressed air are less compared to the neutral atmosphere.

(Dr. Ralph Weyandt)

TOP 3: LENTO as a washing machine

"FRESENIUS Institute" test: Proven reduction of contamination

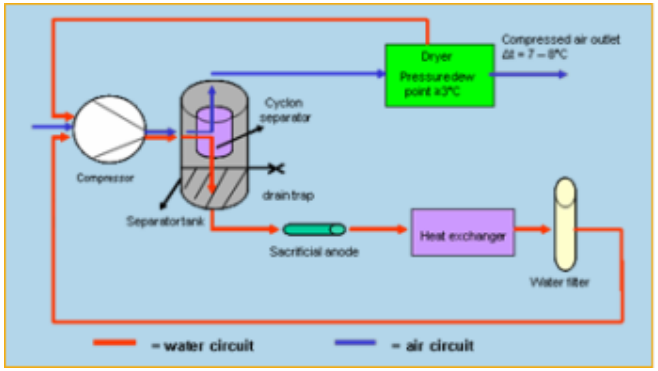
IN			OUT	
Oil	100%		Class "0"	Oil
Particles	100%		~ 18%	Particles
Bacteria	100%		**< limit of measurement**	Bacteria*1

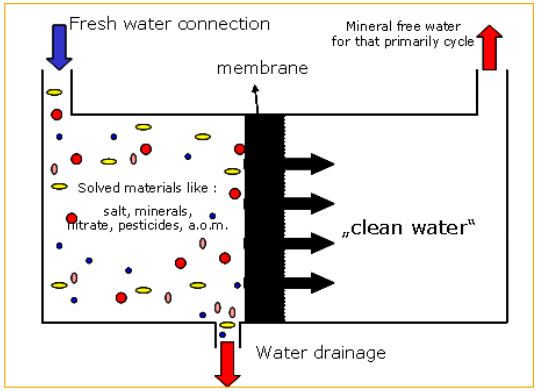
The compressed air is "washed clean" by the LENTO!!

*1 Why is the compressed air free from bacteria / viruses / germs / fungi?

- Owing to the constant replacement of the "cooling water" inside the LENTO
- The internal pressure kills off the "living cultures"
- The cooling water / condensate from the refrigerant dryer is "biologically dead" (quality of an iron)

TOP 4: Water treatment "simple and efficient"





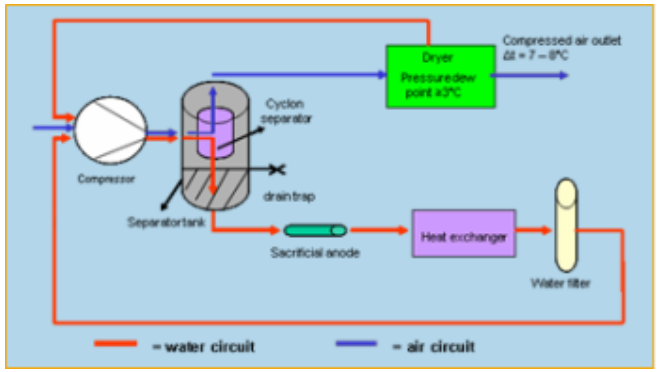
LENTO, simple and safe:

- It produces fresh water independently by means of the integrated refrigerant dryer
- Chalk-free supply of fresh water via the air humidity
  ➔System is always "clean"
- Minerals are constantly being fed into the fresh water by means of a sacrifical anode
  ➔The water does not attack any materials
- Water remains in the system only for a very short time, because fresh water is constantly being produced
  ➔ No viruses / bacteria / algae

Elaborate treatment "Osmosis"

- A permanent supply of fresh water from the outside is required -> costs of laying pipes
- Dissolved chalk can enter the system via the fresh water
  ➔System can become congested
- Demineralised water makes material age
  ➔Poor operational reliability
- The water remains in the system for a long time because only the water consumed via the residual water content of the compressed air is replaced hence
  ➔a fast aging process

TOP 4: Water treatment “simple and efficient”



Basis of calculation: $m_{water\ in} = \frac{f_{max_{TU}} \cdot \varphi_1 \cdot V_1 \cdot 60}{1000}$

Air temperature at intake [°C]
(Temperature at installation location)
30

Relative humidity of intake air φ_1 [%]
60

Compressor delivery volume V_1 [m^3/min]
7,7

Final compression pressure P_2 [bar ü]
8

calculate

Quantity of water taken into the compressor ($m_{water\ in}$)
8,41 [l/h]

Example calculation for fresh water production:

- LENTO 55
- Volumetric flow rate = 7.7 m³/min (8 bars)
- Water volume when filled = 72 L
- Ambient temperature = 30° C
- Moisture = 60%

$$\frac{72\ L}{8.4\ L/h} = 8.5\ h$$

The water inside the LENTO is exchanged every 8.5 hours

- Short time in system because a great deal of freshwater is constantly being produced
  - Level sensors have to be built in to ensure that excess water is drained off
  - The water can be discharged into the sewerage system without any treatment

TOP 5: Easy maintenance

The time and costs for maintenance of the LENTO are limited to a minimum compared to other compressor systems

Maintenance items	LENTO	Water screw with "osmosis"	Oil-free, 2-stage screw	Rotary	Oil-lubricated screw
Change air filter	X	X	X	X	X
Check intake control valve	X	X	X	X	X
Change water filter	X	X	-	-	-
Check condensate drain	X	X	X	X	X
Lubricate compressor bearings	via nipple (LENTO 15 - 55) permanent lubrication (LENTO 46 – 110)	X	-	?	-
Lubricate motor bearings	X	X	X	X	X
Change osmosis filter	-	X	-	-	-
Change oil filter	-	-	X	X	X
Change	-	-	-	-	X
Change/check drive (gear / V-belt)	-	X	X	X	X
Oil change	-	-	X	X	X

TOP 5: Easy maintenance

Access to all components / maintenance items is easy via panels which are easy to remove

- Less time required for maintenance
- Maintenance is cheaper
- LENTO downtimes are reduced to a minimum

TOP 6: Electronic Fail-Safe System

As standard, the LENTO is designed for 100% continuous load (400V / 40° C ambient temperature)

Used under extreme conditions, e.g.:

- Load > 100%
- Voltage > 400V
- Ambient temperature > 40° C

→ If power consumption and the load on the electronic components increases

LENTO

Not to be switched off (!)

FSS of the compressor is activated and switches into the secure mode

➔Compressor works at a reduced speed

➔"Better less air than none at all"

➔Compressed air supply is maintained

➔Parameters reset as soon as power consumption becomes normal

Conventional compressors

Switching off the compressors (!)

- compressors switch to error, e.g. "over current"
- Compressed air supply is stopped = "0" delivery volume

TOP 7: Economic efficiency

Speed-controlled direct drive:

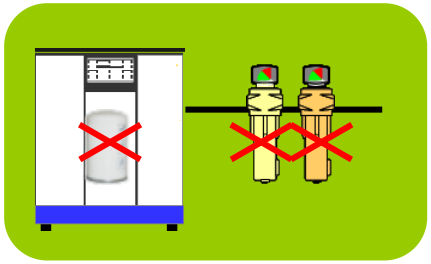
- Low on maintenance and high on efficiency (η = 99.9%)
- Optimal adaptation of the delivery volume to the current compressed air requirements
  - ➢ Energy savings up to ~ 25%

Condensate = pure water:

Absolutely clean condensate

- ➢ Can be discharged directly into the sewage system (without costly treatment)
- ➢ No consequential costs

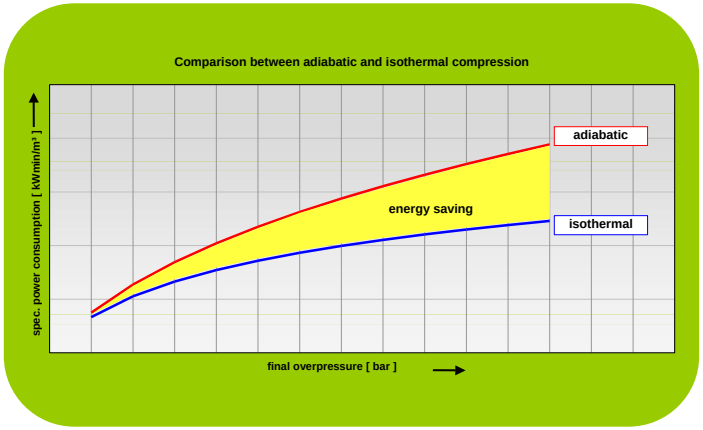
TOP 7: Economic efficiency



Compared to oil-lubricated systems:

1. No fine separator
2. No filter battery necessary for producing oil-free compressed air
   - ➢ No pressure loss = money saved

Example: 55 kW / 3,000 operating hours / Δp = 1 bars / 0.10 €/kWh
1 bar pressure loss. Pressure = 7 – 8% more energy
(7% of 55 kW) x 3000 operating hrs x 0.10 €/kWh = ~ 1150.- €



Isothermal compression:

- Compared to oil, water possess a much better heat absorption capacity
- Water is also much easier to be atomised during injection
  - ➢ Very low final compression temperatures of significantly below 140° F
  - ➢ Compression process very close to the isothermal compression
  - ➢ Better compression efficiency
  - ➢ Greater economic efficiency

TOP 7: Economic efficiency

$P_{spez.} = P/V$

$= [\ \frac{KW}{m^3/min}\ ]$

Pspec. compared to other alternative systems

	LENTO 46	Rotary ZR 50 VSD	2-stage oil-free ZR 55 "fixed speed"
Pspec = (with refrigerant dryer)	6.0	7.7	7.1
Pspec = (without refrigerant dryer)	-	7.6	6.8

with reference to:
55 kW / 7.5 bars / P_{shaft} / water-cooled

Example: A customer requires 2,000,000 m³ of dry compressed air per year

LENTO 46: $\frac{2{,}000{,}000\ m^3/year}{8.3\ m^3/min}$ = 4016 h x 49.4 kW * 0.1 €/kWh = 19840 €

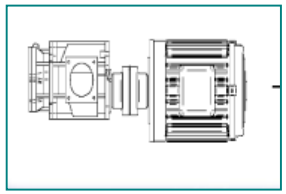
ZR 50 VSD: $\frac{2{,}000{,}000\ m^3/year}{7.3\ m^3/min}$ = 4566 h x 56.4 kW * 0.1 €/kWh = 25750 €

ZR 55: $\frac{2{,}000{,}000\ m^3/year}{7.8\ m^3/min}$ = 4273 h x 56.3 kW * 0.1 €/kWh = 24060 €

TOP 8: Operational reliability

Drive: Direct drive vs synchronous gear

Like this



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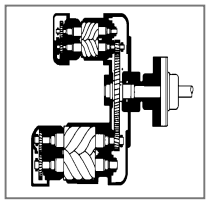


Note:

2-stage structure applies to:

a) Oil-free 2-stage screw
b) Oil-free 2-stage tooth-type rotary compressor (only the compressor element is different)

- The simplest drive system available
  - ✓ Absolutely resilient
  - ✓ No maintenance
  - ✓ Highest possible efficiency (η ~ 99.9%)
- Low speeds (~ 1,000 – 5,000 rpm)
  - ✓ Little strain on the mechanical components
  - ✓ No oil in the compressor

- With a highly complex gear
  - Expensive if worst comes to worst
  - Requires much maintenance
  - Transmission losses per gear (η ~ 98%)
- High speeds (>20,000 rpm)
  - Great strain on the mechanical components
  - Oil cooling for bearings / gears mandatory (Example: ZR 55 = 30L oil)

TOP 8: Operational reliability

Bearing technology of the water-injected airends: Grease lubrication vs. water lubrication

LENTO:

- Roller bearings w. grease lubrication

✓ Tried and tested, absolutely bearing technology

✓ Grease with far better lubrication properties than water

✓ maximum operational reliability

✓ low maintenance requirements

Note:

LENTO 15 - 55
(grease-lubricated bearings; lubricate every 4,000 h)
LENTO 46 - 110
(life-time lubrication)

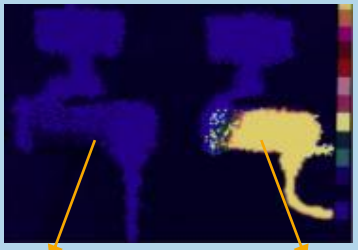
Competition:

- Water-lubricated sliding bearings

If water supply fails immediate stoppage due to damaged bearings

System significantly more complicated and susceptible than with standard bearings

TOP 8: Operational reliability



Final compression temperatures:
1-stage water injection:
vs.
2-stage "dry" compression

1-stage water injection

As a cooling medium water ensures the lowest final compression temperatures (Δt airend max. 20K above intake temperature)

- ✓ Close to the isotherm -> economic efficiency
- ✓ Single-stage compression is possible
- ✓ It is possible to forego an aftercooler
- ✓ Few components -> high operating reliability
- ✓ Can be installed even at worse ambient temperatures

2-stage "dry" compression

Since there is no cooling medium in the airend, the final compression temperature is very high (Δt airend at least 170K above intake temperature)

- High temperature – poor economic efficiency
- 2nd stage compression is necessary
- 3 coolers are required (1x oil, 2 x air)
- Significantly more components -> poor operational reliability / higher costs
- Can only be installed at worse ambient temperatures under certain circumstances

TOP 8: Operational reliability

Water level sensors:

- Safe monitoring by means of 2 sensors (min. and max.)
  - ➢"Overflow" or is not possible to „overrun" or „run dry"

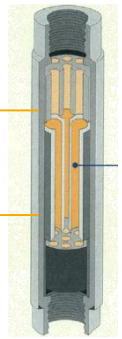
Stainless steel piping:

- Entire compressor is equipped with stainless steel piping
  - ➢ No hoses installed

Liquid-tight frame:

- The base frame is designed as a liquid-tight frame (ISO 14001)

TOP 8: Operational reliability



Zinc sacrificial anode

The sacrificial anode ensures that:

- The water is balanced in terms of minerals
- Spent minerals are returned to the water,
  - Water-conductive parts are not adversely affected
- Chalk is kept "suspended" and does not form deposits
- The system is absolutely low on maintenance

This clever system is used in many applications, for example as corrosion protection in shipbuilding.

Function:

A conductive connection is made between the metal to be protected and the sacrificial anode.
The result is a primary element, in which the metal requiring protection functions cathode and the less precious metal as an anode. This causes a flow in the direction of the metal to be protected. Now the less precious sacrificial anode metal now emits its electrons into the oxygen, is oxidised and dissolves. In this local element the water is the electrolyte, which facilitates conveyance of the loaded particles and thus closes the circuit. Over time the sacrificial anode is spent and must be renewed.

TOP 8: Operational reliability

The water pump ensures that:

- The internal water pressure has built up before the compressor starts up
  - All important components are supplied with water
  - The mechanical seals are moistened with water
  - Full operational reliability is provided

AIR CONTROL 3:

- Pressure infinitely adjustable in 0.1-bar stages
- All important operating information can be read off the graphic display
- Base load change possible for 1 master + 8 slaves
- The refrigerant dryer is also managed via the control system

TOP 9: … and what else?

Energy-saving duo:

The modular system enables the energy-saving duo to be used. It consists of:

1. A LENTO plant is a direct-driven, “fixed” and
2. A LENTO plant is a direct-driven, speed-controlled compressor
   - The fixed-speed compressor covers the base load requirements
   - The speed-controlled compressor follows the “peaks”
   - Total economy

TOP 9: … and what else?

Small footprint:

- Thanks to the "simple" water treatment system it is possible to design the LENTO plants to be significantly smaller than other oil-free systems
  - ➢If space is a problem, the LENTO is exactly the right thing!

ALMiG warranty:

- ALMiG provides the same warranty for the water-injected LENTO as for all other "oil-injected" plants

TOP 10: The ALMiG quality standard

TÜV CERT ISO 9001

TÜV CERT ISO 14001

IRIS Certification

RINA 1861

GERMANISCHER LLOYD 1867

UL

ABS

CE

DNV

BUREAU VERITAS 1828 BUREAU VERITAS

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