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CO2 Compression Challenges

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CO2 has been used for a very long time, for instance in the food industry, and most applications have required it to be compressed. For Sequestration or Enhanced Oil Recovery, the traditional approach to CO2 compression has been to use high-speed reciprocating compressors. The main reasons are:

- Flexibility with regards to pressure ratio, and capacity (if equipped with variable speed drive or valve unloaders).
- Short delivery times, since many recip. packagers dispose of a selection of frames and cylinders on stock, and can assemble a package in a few months.
- Light-weight skid-mounted units can be relocated at will.
- Familiarity of the field operators with these machines (frequently used at the well site for natural gas service) and their suppliers.

A number of factors however favor using centrifugal compressors for such application:

- The capacity of most CO2 recovery schemes today exceeds the range of reciprocating compressors.
- Reciprocating compressors are maintenance intensive.
- The high density of CO2 may cause problems with high velocities (valves).
- Slow speed recips. require massive foundations.
- i. e. high capital and operating costs.

By comparison, centrifugal compressors offer:

- Superior efficiency.
- Oilfree compression.
- Higher speed, better matched to the high-speed drivers (electric motors or steam turbines) commonly used in the 10-40MW range.
- By design, they are much less maintenance-intensive, leading to considerably extended intervals between overhauls.

Within the centrifugal compressor markets, there are still 2 technologies, namely in-line (between bearings) centrifugals and integral-gear centrifugals. MAN TURBO manufactures both and has applied both in CO2 service. We have come to the conclusion that, for most CO2 applications, the integral-gear design offers undeniable advantages:

- Higher efficiency, thanks to:
  - Optimum impeller flow coefficient, due to the fact an optimum speed can be selected for each pair of impellers.
  - Axial in-flow to each stage
  - Shrouded or unshrouded impellers can be used.
  - Small hub/tip ratio.
  - Intercooling possible after each stage (impeller)
- External connection after each stage gives more flexibility in selecting the pressure level for the dehydration system, if applicable.
- Contrary to in-line compressors, there is practically no limit to the possible number of stages in one machine (pressure ratio of 200 is possible on a single frame).
- Integral-gear compressors can be direct-driven by a 4-pole electric motor on the bull-gear, or a steam/gas turbine on one of the pinions.

All the features of these machines are well-proven and many references exist in various services and frame sizes:

- Design has existed for 30 years or more.
- Engineered units built up to 10 stages (5 pinions).Unit power range up to 30 MW commonly used, for instance in air separation plants.
- Can be equipped with all the current range of sealing systems.
- Integral-gear compressors now recognized by API 617.
- Reliability and interval between overhaul considered comparable to in-line design.

In conclusion, and based on our experience, integral-gear compressors have definite advantages over in-line centrifugals in most CO2 service:

- In-line compressors require approx. twice the number of stages than do integral-gear compressors, leading often to one or two additional casings.
- Integral-gear compressors have higher efficiency.
- Integral-gear compressors have comparable maintenance requirements as in-line compressors.

The integral-gear compressor is a proven, reliable, and cost effective solution for CO2 service.

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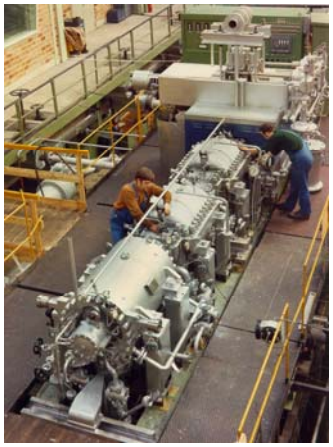
In-line centrifugal



Integral-gear centrifugal

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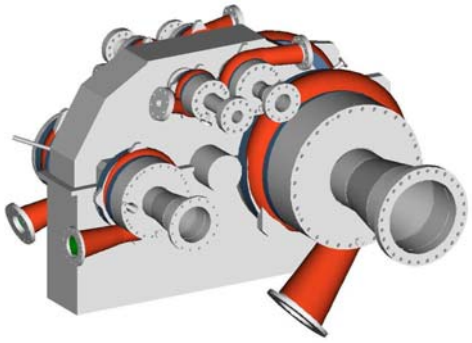
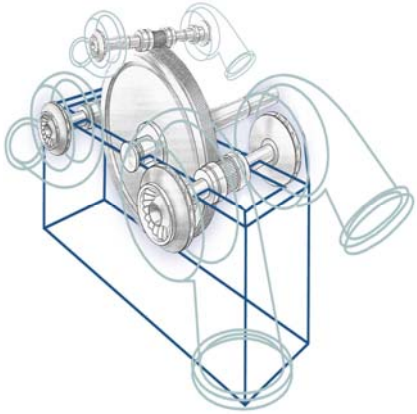
- **Integral-gear centrifugal compressor**





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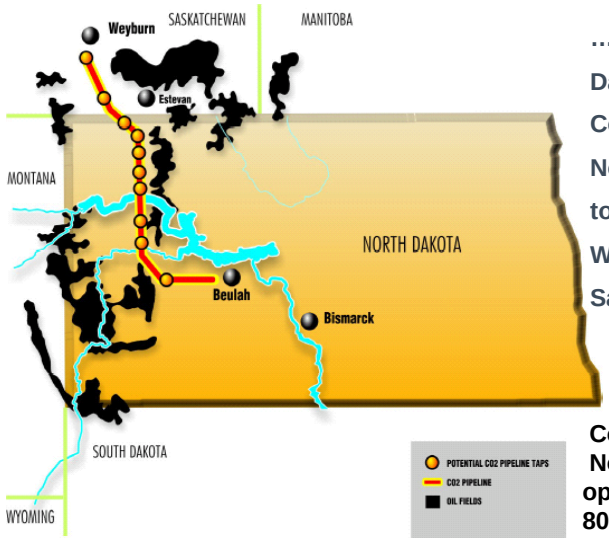

…. from

Dakota Gasification Company, Beulah, North Dakota, USA to ENCANA, Weyburn Oilfield, Saskatchewan, Canada

Compressors in North Dakota are now in operation with more than 80.000 hours in common

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CO2 Compression

Typical reference:

- 8-stage Integral-gear Compressor (CO_2) for Gas Injection
- Type RG 80-8
- Flow: 68 760 m³/h
- Pressure: 1.15 bar - 187.0 bar
- Power: 13 235 kW

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Pressure ratio of 200 possible on a single frame. Example:

- 10-stage compressor
- Urea synthesis
- Type RG 53-10
- Gas Moist CO_2 mix
- Flow rate 23,500 m³/h
- Pressure 1 - 200 bar
- Power 4,500 kW

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Well-proven HP CO2 compressors are here today.

Thank you for your attention

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Powered by experience