[Dynamic compressors](https://www.sciencedirect.com/science/article/pii/B9780128098950000089)

Maurice Stewart, in [Surface Production Operations](https://www.sciencedirect.com/book/9780128098950), 2019

8.1.1 Background

Dynamic compressors are subdivided into [centrifugal and axial compressors](https://www.sciencedirect.com/topics/engineering/centrifugal-compressors). [Centrifugal compressors](https://www.sciencedirect.com/topics/engineering/centrifugal-compressors) are by far the most widely used dynamic compressor and thus will be emphasized in this chapter. [Axial compressors](https://www.sciencedirect.com/topics/engineering/axial-compressors) are similar in operation to that of a [centrifugal compressor](https://www.sciencedirect.com/topics/engineering/centrifugal-compressors) but are rarely used in upstream operations. A separate section in this chapter will discuss axial compressors in detail.

Operation of a dynamic compressor is based on the basic principles of thermodynamics. In the [polytropic compression process](https://www.sciencedirect.com/topics/engineering/polytropic-compression-process), work is done on a fluid so as to raise its pressure. Dynamic compressors are better suited for constant operating conditions due to their narrow operating range.

Compression is achieved by applying [inertial forces](https://www.sciencedirect.com/topics/engineering/inertial-force) to the gas by the bladed [impellers](https://www.sciencedirect.com/topics/engineering/impellers). Velocity energy (acceleration) is added to the gas by the rapidly rotating impeller. Part of this energy, approximately two-thirds, results in a static pressure rise of the gas in the impeller. After leaving the impeller, the gas enters a [diffuser](https://www.sciencedirect.com/topics/engineering/diffusers), which is a stationary component, where it slows down (decelerates) resulting in an additional pressure increase. After leaving the diffuser, the gas either exits the [compressor case](https://www.sciencedirect.com/topics/engineering/compressor-case) after single-stage compression or enters the eye of the next impeller for [multistage](https://www.sciencedirect.com/topics/engineering/multistage) compression.

Dynamic compressors are more reliable than other types of compressors because they do not have reciprocating components that experience [cyclic stress](https://www.sciencedirect.com/topics/engineering/cyclic-stress) while in service. Generally, one should select [centrifugal compressors](https://www.sciencedirect.com/topics/engineering/centrifugal-compressors) unless there is a specific reason not to do so, since they:

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Have the widest range of operation

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While less efficient than [positive displacement compressors](https://www.sciencedirect.com/topics/engineering/reciprocating-compressor), they are more reliable

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Run unspared in many high-value processing facilities and plants

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Are the baseline compressor selection

Typical centrifugal [compressor applications](https://www.sciencedirect.com/topics/engineering/compressor-application) include:

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Associated gas gathering

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Gas plant compression

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Pipeline compression

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High-capacity [refrigeration](https://www.sciencedirect.com/topics/chemical-engineering/refrigeration)

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High-capacity plant/process air systems

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Process gas recycle

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Gas lift/injection

Table 8.1 summarizes typical application ranges of centrifugal compressors. As presented in Table 8.1, the centrifugal compressor is the most versatile type of compressor with the widest application range. Some specific selection notes are listed as follows:

Table 8.1. Typical application ranges of centrifugal compressors

| **ICFM** | **Typical** | **1500–100,000** |
| --- | --- | --- |
|  | Low | 500 |
|  | High | 180,000 (360,000 for double suction) |
| **Discharge CFM (DCFM)** | Low | 250 (can be lower with special designs) |
| **Discharge pressure, psig (bar)** | Typical | 15–4000 (1–276)a |
|  | High | 10,000 (one design has been tested at 13,000) |
| **Discharge temperature, °F (oC)** | Typical | 250–300 (121–149) |
|  | High | 350 (with oil seals) |
|  |  | 500 (with labyrinth seals) |
| **No. of impellers per casing** | Available | 1–10 |
|  | High | 8–10 (to 20,000 ICFM) |
|  |  | 6–7 (20,000–40,000 ICFM) |
|  |  | 4–5 (&gt; 40,000 ICFM) |
| **Adiabatic head per stage, ft** | Typical | 8000–10,000 |
|  | High | 13,000 (special to 30,000) |
| **Speed, RPM** | Typical | 3000–14,000 |
|  | High | 30,000 (special to over 50,000) |
| **BHP per casing** | Typical | 1000–20,000 |
|  | High | over 50,000 |

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Each lower [pressure casing](https://www.sciencedirect.com/topics/engineering/casing-pressure) may have up to three pairs of intermediate nozzles (8 nozzles total) for connecting [intercoolers](https://www.sciencedirect.com/topics/engineering/intercoolers). This means that one casing can have as many as four sections of compression, but typically only three sections per casing are used. Note that only one intermediate nozzle is required to introduce or extract each sidestream. Some refrigeration compressors have as many as three sidestreams.

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As many as four casings have been driven in tandem without interposed gear. Two casings in tandem are common as are two casings separated by a gear.

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[Polytropic efficiency](https://www.sciencedirect.com/topics/engineering/polytropic-efficiency) varies widely from about 60% at low ICFM to over 80% at very high ICFM. Efficiency also varies inversely with number of impellers in series.

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1000 ICFM or 1000 BHP is about the minimum economic sizes in API machines. Refrigeration class machines down to 500 BHP are available.

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Noisy without acoustic treatment

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Stable operating range for one multistage casing is usually about 30% at constant speed. Further capacity reduction at constant speed can be done by (1) variable inlet [guide vanes](https://www.sciencedirect.com/topics/engineering/guide-vane) on first stage (fairly efficient), (2) suction or discharge throttling (less efficient), or (3) bypass (inefficient). When two or more casings are driven in tandem, the overall stable operating range is reduced. Stable operating range varies inversely with number of impellers in series.

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10 impellers per casing are generally recommended. Use a maximum of 8 impellers per casing for initial estimating.

The remainder of this section covers the fundamentals of centrifugal compressors, describing the gas flow path, conversion of velocity to pressure, [thermodynamic relationships](https://www.sciencedirect.com/topics/engineering/thermodynamic-relationship), and the effect of component geometry on [compressor performance](https://www.sciencedirect.com/topics/engineering/compressor-performance).

These fundamental principles provide a basic foundation for troubleshooting performance problems, making rerating or initial selection estimates, evaluating vendor proposals, engineering compressor applications, and assisting with overall process design.

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