Multi-Stage Centrifugal Compressors

Reliably serving the energy industries

The world turns to Elliott

COMPRESSORS

Evolutionary Designs Revolutionary Results

A History of Innovation and Success

Since 1910, Elliott Company has earned a reputation for providing innovative solutions, unmatched expertise, and first-class service to the global turbomachinery marketplace. Elliott has designed, tested, and installed some of the industry's most rugged and dependable equipment. In fact, some Elliott compressors and turbines installed in the 1940s and 1950s are still in operation today, either as originally supplied or upgraded to handle new process conditions or more stringent environmental standards.

We have been on the cutting edge of technological advancement throughout our history, consistently providing advanced technology in aerodynamics, rotor dynamics, process simulation, and metallurgy. Our customers have benefited from our state-of-the-art production innovations, including fabricated casing technology, high-pressure casing technology, and impeller welding techniques. The Elliott EDGE™ development program evolved from our commitment to providing new approaches, processes, and technology while maintaining the quality and reliability that our customers have come to expect.

We understand that change is essential in achieving and maintaining a competitive edge in today's business environment. Together with our customers and suppliers, we continue to innovate, improve, and expand our extensive portfolio of products and services that serve the energy industries.

Product Lines

- Single/Multi-Stage Centrifugal Compressors (API 617)
- Axial Air Compressors (API 617)
- Single/Multi-Stage Steam Turbines (API 611)
- Multi-Stage Steam Turbines (API 612)

Applications

- Oil Refineries
- FCC Applications
- Chemical/Petrochemical Plants
- Ethylene Plants
- Gas Lift/Gas Gathering
- Gas Injection/Transport
- LNG Facilities
- Gas to Liquids
- Ammonia Plants
- Power Generation

Advanced Technology

Superior Performance Through Advanced Technology

Through our EDGE development program, we combine our comprehensive knowledge of turbomachinery with the latest design software, manufacturing processes, and machine tools. As a result, Elliott's multi-stage centrifugal compressors lead the industry in both performance and reliability.

Increased Aerodynamic Efficiency

Elliott uses state-of-the-art interactive design and prediction tools to optimize aerodynamic performance and increase flange-to-flange efficiencies. Compressor impeller and matched stationary flowpath components are developed using Computational Fluid Dynamics (CFD) analyses and other current design tools. Three-dimensional blade profiles, diffuser flow angles, crossover bend curvature, area ratio, and return channel vane shapes are optimized for each impeller stage to provide the best possible efficiency. Additional performance enhancements are achieved by improving the flow distribution channels at the inlet and discharge volutes and sidestream mixing areas. These enhancements allow us to provide some of the industry's highest operational efficiencies.

Improved Rotor Stability Characteristics

Through extensive research in the fields of rotor-dynamic stability, aerodynamic cross-coupling stiffness, and rotor-bearing systems, we have developed proprietary analytical tools. Incorporating these developments into Elliott compressor designs has produced a number of product enhancements. For example, we've increased rotor stiffness by increasing shaft diameter, reducing impeller weight, and increasing journal bearing sizes. This allows higher torque transmission capabilities and higher-speed operation, with improved rotor stability characteristics, which are essential as gas densities and operating pressures increase.

Casing Features

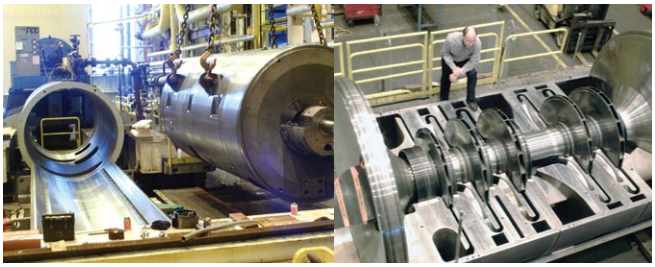
We Perform Under Pressure and Make Field Assembly Easier

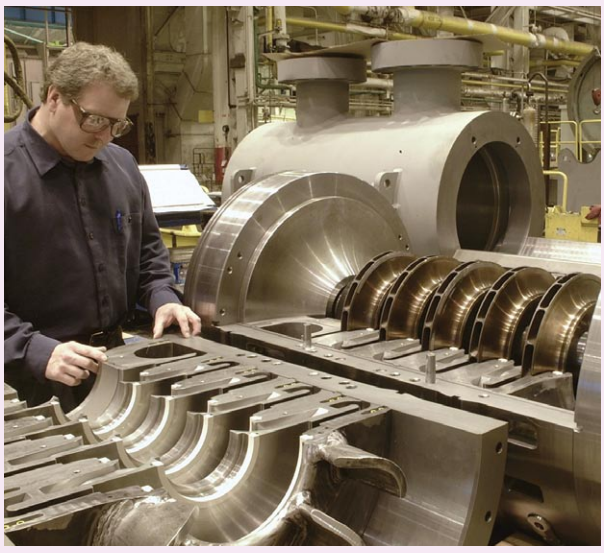
Elliott designed our EDGE compressor casings to reduce the required manufacturing steps and simplify field assembly. To achieve higher operating pressures, we applied state-of-the-art solids modeling and finite element analysis techniques.

Small and mid-sized horizontally split casing sections are made from a single piece of rolled steel plate with horizontal flanges that are machined—not welded—into the side. Cast steel casings are used for some applications. High-strength casing through-bolts provide superior clamping forces. Endwalls are made from a single solid plate. The resulting casing has fewer sealing surfaces, is easier to manufacture and assemble, and has increased pressure capabilities compared to conventional designs. Larger horizontally split casings have rolled barrel sections with welded-on endplates and welded-on horizontal flanges.

Vertically split MB-line compressors feature a complete inner casing assembly. This includes a horizontally split inner casing with diaphragms, stationary seals, rotating elements, bolted-on endwalls, and shaft end seals. This module can be inserted or removed from the outer casing as a single piece, which simplifies compressor assembly and reduces turn-around times.

We typically use milled flats for SAE flanged connections, including endwall, spray nozzle, casing drain, bearing retainer, and equalizing line connections. On smaller casings where space is limited, SAE flanges provide higher ratings and more compact designs than ANSI flanges.





EDGE Casing Advantages

- Integral horizontal flanges on small and medium frames
- Solid endwalls with machined flats for bearing and seal connections
- Machined flats with SAE flanges for most drain or injection connections
- Through-bolts for casing horizontal flanges
- Allowable forces and moments per API 617
- Three-dimensional solid modeling for improved design and engineering review capability
- Pro/ENGINEER solid modeling files to enhance precision during component manufacture

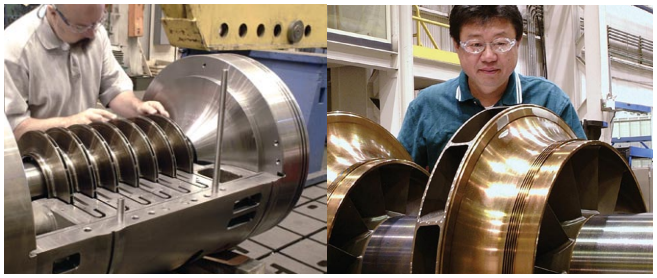
Aerodynamic Components

Advanced Aerodynamics and Enhanced Performance Give Our Customers the EDGE

A key achievement of the EDGE development program is our ability to offer superior, three-dimensional impeller designs and stationary diaphragms. We do this by maximizing performance over a broad range of pressure and flow applications using the latest aerodynamic design and analysis technologies. To verify predicted performance, single-stage testing is performed in various configurations, such as with vaneless or vaned diffusers, or using high or low tip Mach numbers. Higher and lower flow stage ratings are derived from the prototype test data to form a "family" of stages. Within each stage family, impeller geometry is fixed; blade heights are varied for higher or lower flows. Using this methodology, several stage families are used to span the desired flow coefficient range. Impellers and stationary components are then scaled up or down for different frame sizes. For maximum flexibility, EDGE aerodynamic components are also scalable from 90 percent to 100 percent size within each compressor
frame size.

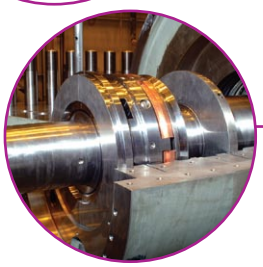
Impeller manufacturing applies five-axis milling to ensure the quality of the advanced impeller designs. Impellers are stress relieved, machine finished, balanced statically and dynamically, spin tested, and then mounted with an interference-fit onto the shaft. Shaft-to-impeller keys are used for extra stability in high pressure or high power applications.

EDGE compressors use either fabricated steel diaphragms or a combination cast-and-fabricated steel design where thickness precludes using steel plate alone. Precision machining ensures dimensional accuracy and significantly improves the diaphragm surface finish. Diaphragms are horizontally split and finished at all horizontal and peripheral joints and on gas path surfaces.



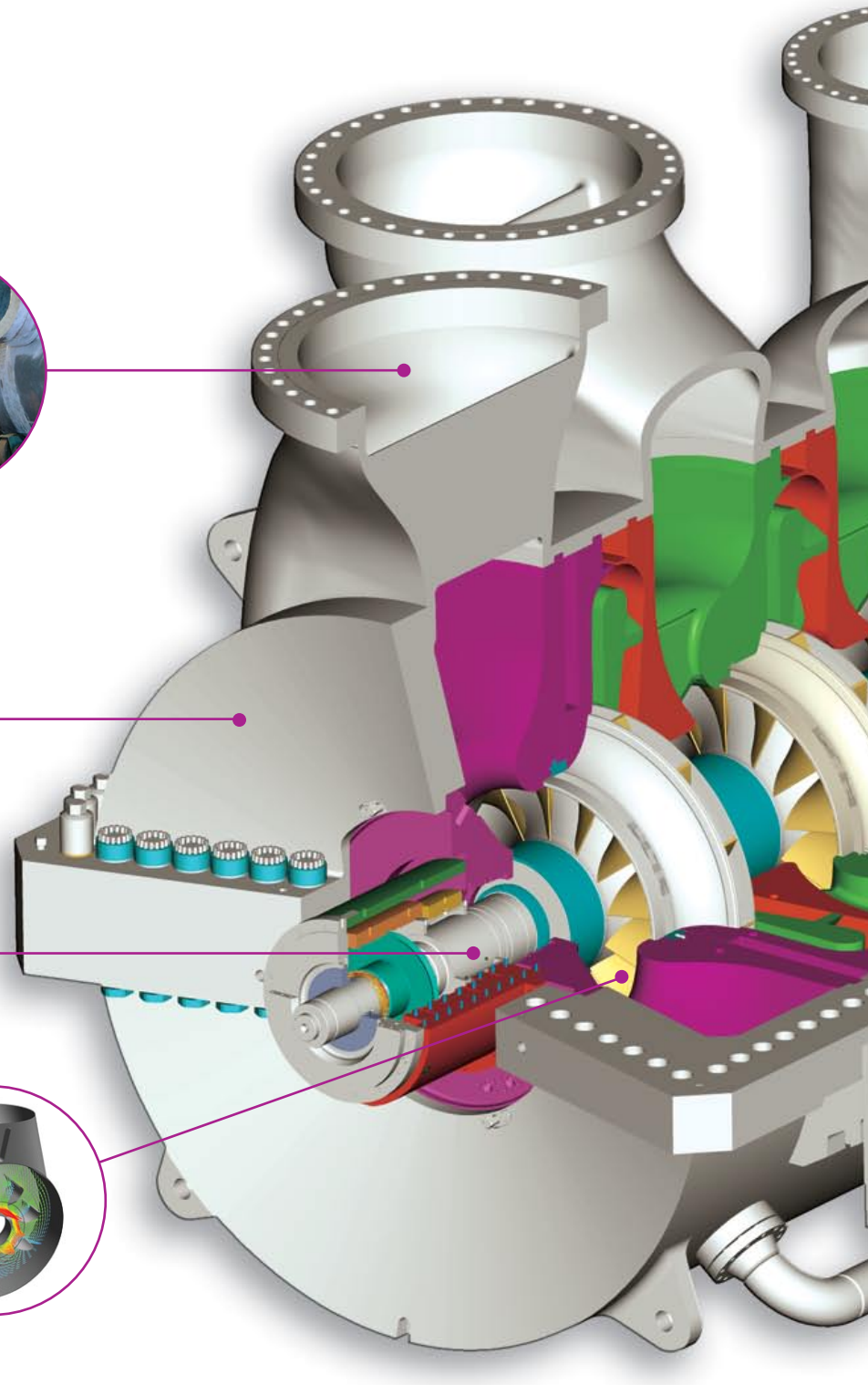
Cast nozzles reduce manufacture time
and allow higher ratings

Elimination of dished heads
increases pressure ratings



Increased journal bearing
and shaft seal sizes

Non-radial inlet guide vanes
improve flow distribution



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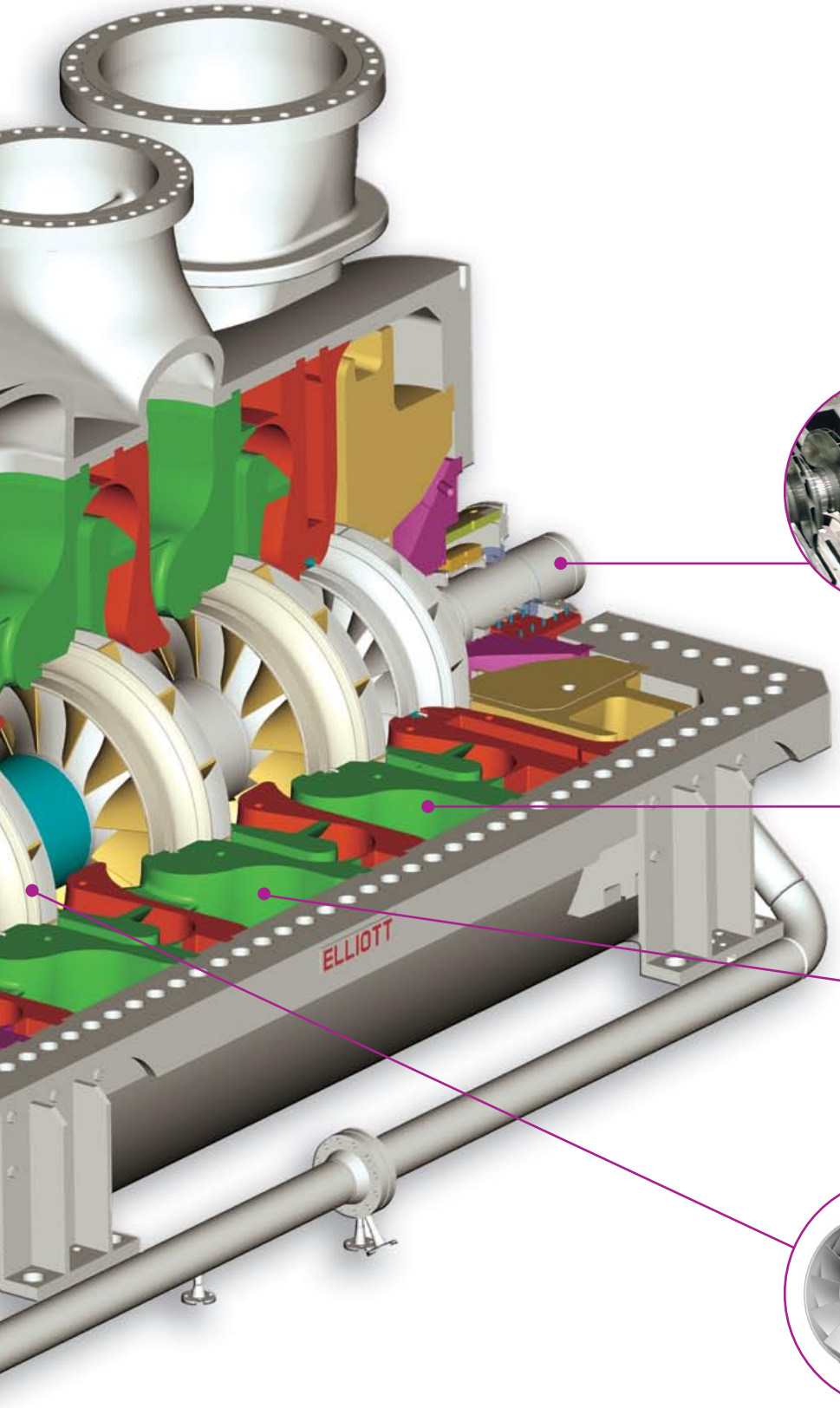
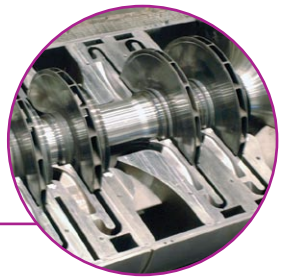
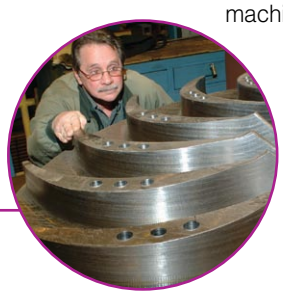
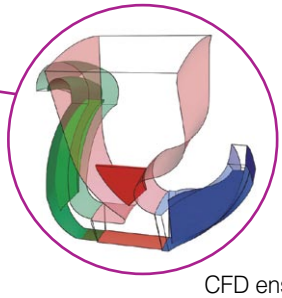


Increased shaft diameter
enhances rotor dynamics

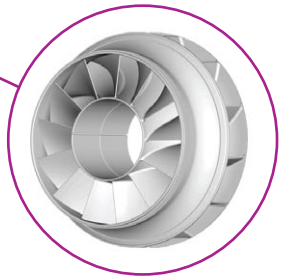


Precisely designed and
machined diaphragms





CFD ensures proper
sidestream mixing



High-efficiency impellers
scale frame-to-frame

Other Features

We've Paid Careful Attention to Every Detail

As part of our comprehensive EDGE development program, Elliott's engineers examined each compressor component to find ways to support our goals of higher efficiency, lower cost, simpler maintenance, and reduced cycle time. Our designs reflect our commitment to making our products the best in the industry, down to the last detail.

Interstage and balance piston sealing is accomplished through two component features. First, we use abradable or deflection-tolerant materials such as fluorosint or nickel-graphite on stationary sealing surfaces. Second, we machine teeth onto the rotating surfaces. These features increase efficiency by reducing gas recirculation and minimizing the potential for shut-downs resulting from damaged seals.

Elliott offers shaft seals to meet our customers' needs in all applications. Dry gas seals are standard and are available as single, tandem, double, or triple designs. The tandem or triple gas seal designs include an intermediate labyrinth, which can be buffered for additional emissions protection. Our customers realize cost savings by eliminating expensive seal oil systems and the need to dispose of contaminated oil. Gas seal buffer system engineering and manufacturing are available at Elliott's Donora, Pennsylvania, plant.

Alternative seal designs include labyrinth or dry carbon ring seals for low pressure services, mechanical contact seals (Elliott's patented Iso-carbon™ design), and bushing seals (Elliott's Iso-sleeve™ design). For mechanical contact and bushing seals, a cartridge design is also available. This enables easier installation and removal of the complete seal assembly. Buffer connections are standard for all seal designs.

Reliability, quality, and safety are hallmarks of all Elliott-designed components. For example, as a design standard, replaceable journal bearings are steel-backed and babbitt-lined with a five-shoe tilting pad. Thrust bearings are double-acting and self-equalizing. Center pivots typically are used to make assembly easier and to provide maximum protection if reverse rotation occurs. Chrome-copper pads are applied for both journal and thrust bearings for high oil temperature applications.

Manufacturing and Testing Capabilities

A Commitment to World-Class Manufacturing

Elliott employs high-quality production techniques that minimize cycle time and costs while providing our customers with the most competitive and reliable products. Our engineering and manufacturing facilities in Jeannette, Pennsylvania, and Sodegaura, Japan, rank among the world's most advanced for turbomachinery design, production, and testing.

Our combined manufacturing capabilities include Masterhead machining centers for casing machining, rotor machining centers, and diaphragm machining centers. Our rotor balancing facilities include a state-of-the-art Schenck Trebel-designed balancing machine housed in a bunker-style vacuum chamber. The top of this reinforced concrete facility slides away via hydraulic motors, permitting rotors to be lowered onto the balancing equipment.

Our recently modernized and expanded test facilities enable us to validate the mechanical integrity and performance of our components and overall systems. Our new main test facility, which increased our capacity by 50 percent, contains a high-volume, closed loop, specially designed cooling system with the capacity for testing gas turbine-driven compressor trains at full loads up to 100,000 HP.

Masterhead casing center

Diaphragm machining cell

High-speed balance facility

Compressor Frame Summaries

Frame	Typical Flow Range (icfm)	Typical Flow Range (m^3/h)	Casing Rating Axial Split (psig)	Casing Rating Axial Split (Barg)	Casing Rating Radial Splite (psig)	Casing Rating Radial Splite (Barg)	Nominal Impeller Diameter (in.)	Nominal Impeller Diameter (mm)	Nominal Speed (rpm)
10M	1,700 - 5,400	2,900 - 9,200	1,000	68.95	—	—	10.38	263.55	19,800
10MB			—	—	10,000	689.48			
15M	2,200 - 7,100	3,700 - 12,100	1,000	68.95			11.93	303.07	17,300
15MB			—	—	10,000	689.48			
20M	2,900 - 9,400	4,900 - 16,000	1,000	68.95	—	—	13.72	348.54	15,000
20MB			—	—	10,000	689.48			
25M	3,900 - 12,500	6,600 - 21,200	1,000	68.95	—	—	15.78	400.81	13,100
25MB			—	—	10,000	689.48			
29M	5,100 - 16,500	8,700 - 28,000	1,000	68.95	—	—	18.15	460.93	11,400
29MB			—	—	10,000	689.48			
32M	6,800 - 21,800	11,500 - 37,000	1,000	68.95	—	—	20.87	530.10	9,900
32MB			—	—	5,000	344.74			
38M	9,000 - 28,800	15,300 - 48,900	1,000	68.95	—	—	24.00	609.60	8,600
38MB			—	—	3,000	206.84			
46M	11,900 - 38,100	20,200 - 64,700	1,000	68.95	—	—	27.60	701.04	7,500
46MB			—	—	2,000	137.90			
56M	15,700 - 50,400	26,700 - 85,600	1,000	68.95	—	—	31.74	806.20	6,500
56MB			—	—	2,000	137.90			
60M	20,800 - 67,000	35,300 - 113,800	1,000	68.95	—	—	36.50	927.13	5,600
60MB			—	—	2,000	137.90			
70M	27,500 - 88,000	46,700 - 149,500	750	51.71	—	—	41.98	1,066.19	4,900
70MB			—	—	1,500	103.42			
78M	36,400 - 117,000	61,800 - 198,800	600	41.37	—	—	48.27	1,226.13	4,300
78MB			—	—	1,500	103.42			
88M	48,100 - 154,000	81,700 - 261,600	600	41.37	—	—	55.51	1,410.03	3,700
88MB			—	—	1,000	68.95			
103M	63,600 - 203,000	108,100 - 344,900	400	27.58	N.A.		63.84	1,621.54	3,200
110M	84,100 - 270,000	142,900 - 458,700	400	27.58	N.A.		73.42	1,864.79	2,800

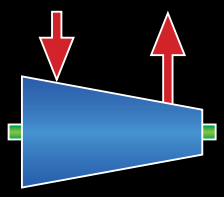
Standardization of Components

In developing the EDGE compressor product line, we focused on standardizing components and hardware to reduce costs and improve reliability across a wide array of applications. The EDGE product line consists of 15 standard frame sizes, which are scaled from the 38M median frame size. Casing bores and internal aerodynamic hardware, such as impellers, diaphragms, and shafts, are scaled. Scaling aerodynamic components improves performance predictability and increases reliability by preserving geometric similarity across frame sizes. Bearings and seals are selected from vendor standard sizes for each application.

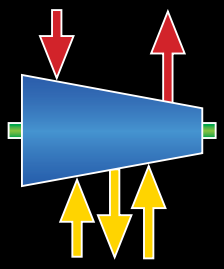
Weights, Dimensions and Configurations

Frame Size	Minimum Rotor Length (in. / mm)	Maximum Rotor Length (in. / mm)	Casing Width (includes supports) (in. / mm)	Casing Height (exc. supports) (in. / mm)	Minimum Casing Weight (lb/kg)	Maximum Casing Weight (lb / kg)
Typical Weights and Dimensions for Elliott Horizontal Split Compressors*						
10M	35 / 890	64 / 1,625	37.3 / 947.4	36.25 / 921	4,700 / 2,130	9,000 / 4,080
15M	35 / 890	75 / 1,905	42.5 / 1,080	41.38 / 1,051	5,600 / 2,540	12,700 / 5,760
20M	40 / 1,015	80 / 2,030	48.5 / 1,232	47.85 / 1,215	8,200 / 3,720	18,000 / 8,165
25M	45 / 1,145	90 / 2,285	55.1 / 1,400	54.12 / 1,375	11,100 / 5,035	24,500 / 11,100
29M	50 / 1,270	110 / 2,795	65.4 / 1,661	59.25 / 1,505	14,000 / 6,350	32,000 / 14,500
32M	50 / 1,270	124 / 3,150	70.5 / 1,791	65.75 / 1,670	15,700 / 7,120	45,000 / 20,400
38M	55 / 1,400	135 / 3,430	76.3 / 1,938	70.62 / 1,794	23,000 / 10,430	62,000 / 28,100
46M	70 / 1,780	155 / 3,940	66.5 / 1,689	89.5 / 2,273	32,500 / 14,740	87,000 / 39,500
56M	80 / 2,032	175 / 4,445	76 / 1,930	93.38 / 2,372	51,500 / 23,360	127,000 / 57,600
60M	90 / 2,285	190 / 4,825	89.7 / 2,278	97 / 2,464	59,000 / 26,760	170,000 / 77,100
70M	100 / 2,540	230 / 5,840	103.5 / 2,629	113.88 / 2,893	71,000 / 34,000	210,000 / 95,250
78M	100 / 2,540	250 / 6,350	109.5 / 2,781	125.5 / 3,188	95,000 / 43,100	295,000 / 133,800
88M	115 / 2,920	275 / 6,985	133 / 3,378	137.5 / 3,492	130,000 / 59,000	380,000 / 172,400
103M	135 / 3,429	300 / 7,620	156 / 3,962	158.5 / 4,025	215,000 / 97,500	525,000 / 238,100
110M	140 / 3,556	325 / 8,255	182 / 4,623	182 / 4,630	270,000 / 122,470	690,000 / 312,980
Typical Weights and Dimensions for Elliott Vertical Split Compressors*						
10MB	35 / 890	62 / 1,575	43 / 1,092	42.5 / 1,080	7,000 / 3,175	13,000 / 5,900
15MB	35 / 890	72 / 1,830	46 / 1,168	48 / 1,219	8,400 / 3,810	17,500 / 7,940
20MB	40 / 1,015	80 / 2,030	50 / 1,270	53.75 / 1,366	12,000 / 5,440	25,000 / 11,340
25MB	45 / 1,145	88 / 2,235	58.5 / 1,486	62 / 1,575	18,400 / 8,345	36,000 / 163,030
29MB	50 / 1,270	105 / 2,670	64.3 / 1,633	64 / 1,626	23,000 / 10,435	49,000 / 22,225
32MB	50 / 1,270	120 / 3,050	71.7 / 1,821	76.5 / 1,943	28,500 / 12,900	69,000 / 31,300
38MB	55 / 1,400	130 / 3,300	78.5 / 1,994	83.25 / 2,115	36,500 / 16,560	89,000 / 40,400
46MB	70 / 1,780	150 / 3,810	96.5 / 2,451	86.5 / 2,197	47,500 / 21,500	115,000 / 52,200
56MB	80 / 2,030	170 / 4,320	104.2 / 2,647	102.12 / 2,594	70,000 / 31,750	160,000 / 72,600
60MB	90 / 1,525	185 / 4,700	113 / 2,870	112.5 / 2,858	90,000 / 41,000	200,000 / 91,000
70MB	100 / 2,540	225 / 5,715	115.2 / 2,926	120.96 / 3,064	100,000 / 45,350	251,000 / 113,900
78MB	100 / 2,540	245 / 6,225	120 / 3,048	140 / 3,556	125,000 / 56,700	315,000 / 143,000
88MB	115 / 2,920	265 / 6,730	137 / 3,480	148 / 3,759	205,000 / 93,000	465,000 / 211,000

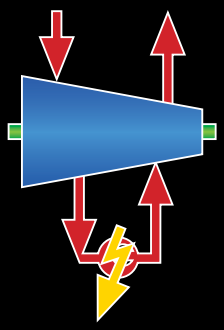
All data are estimates.



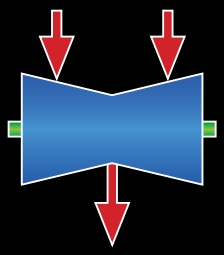
In-Line



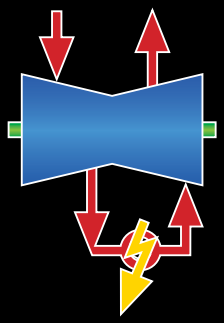
In-Line
with Side-Streams



In-Line
with Iso-Cooling



Double-Flow



Back-to-Back
Iso-Cooler Optional

Elliott Manufacturing and Service Facilities

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EBARA GROUP

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