GAS COMPRESSION
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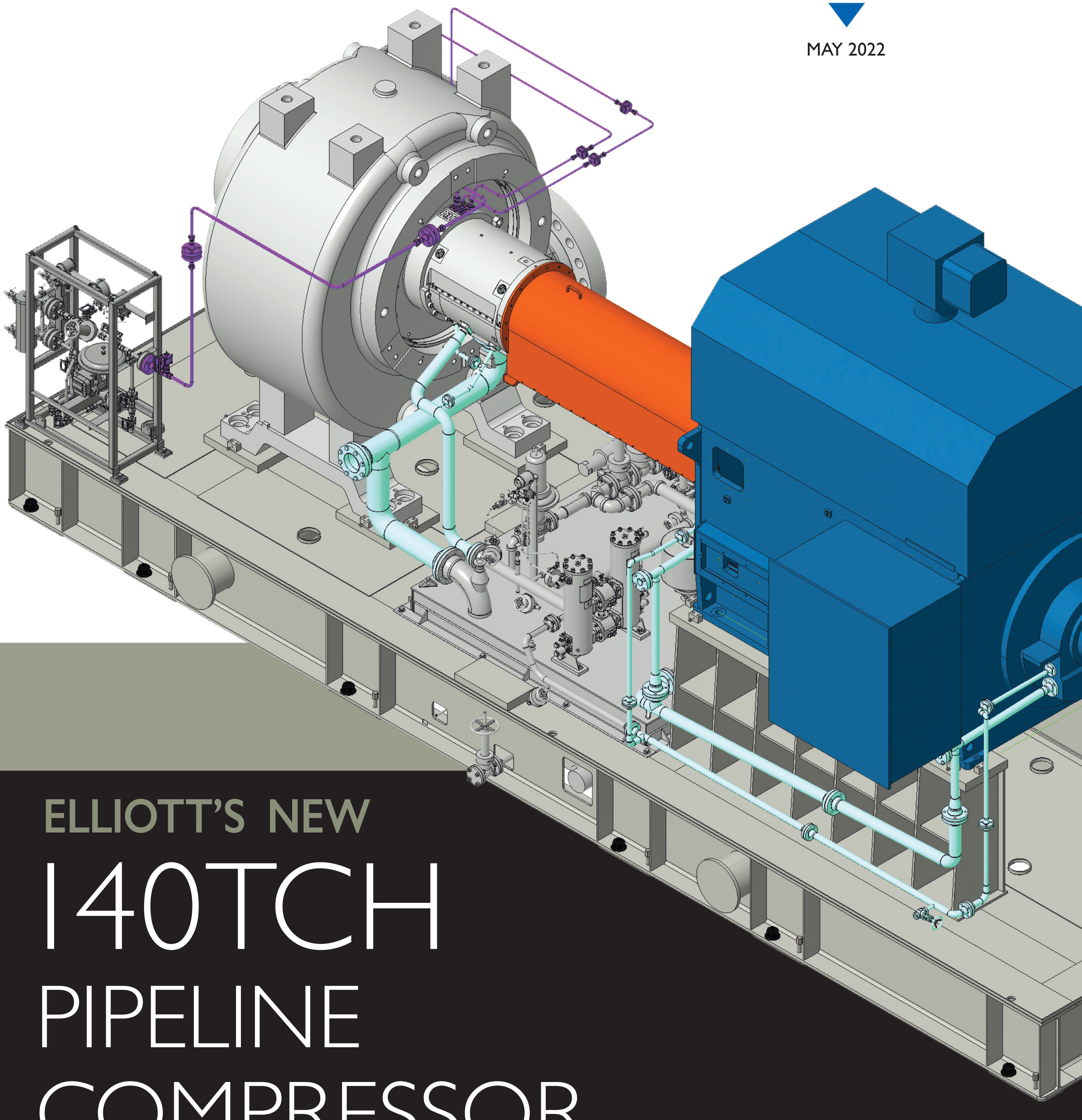

ELLIOTT'S NEW

140TCH PIPELINE COMPRESSOR

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ADVANCED COMPRESSOR TECHNOLOGY TO MEET NATURAL GAS PIPELINE DEMAND

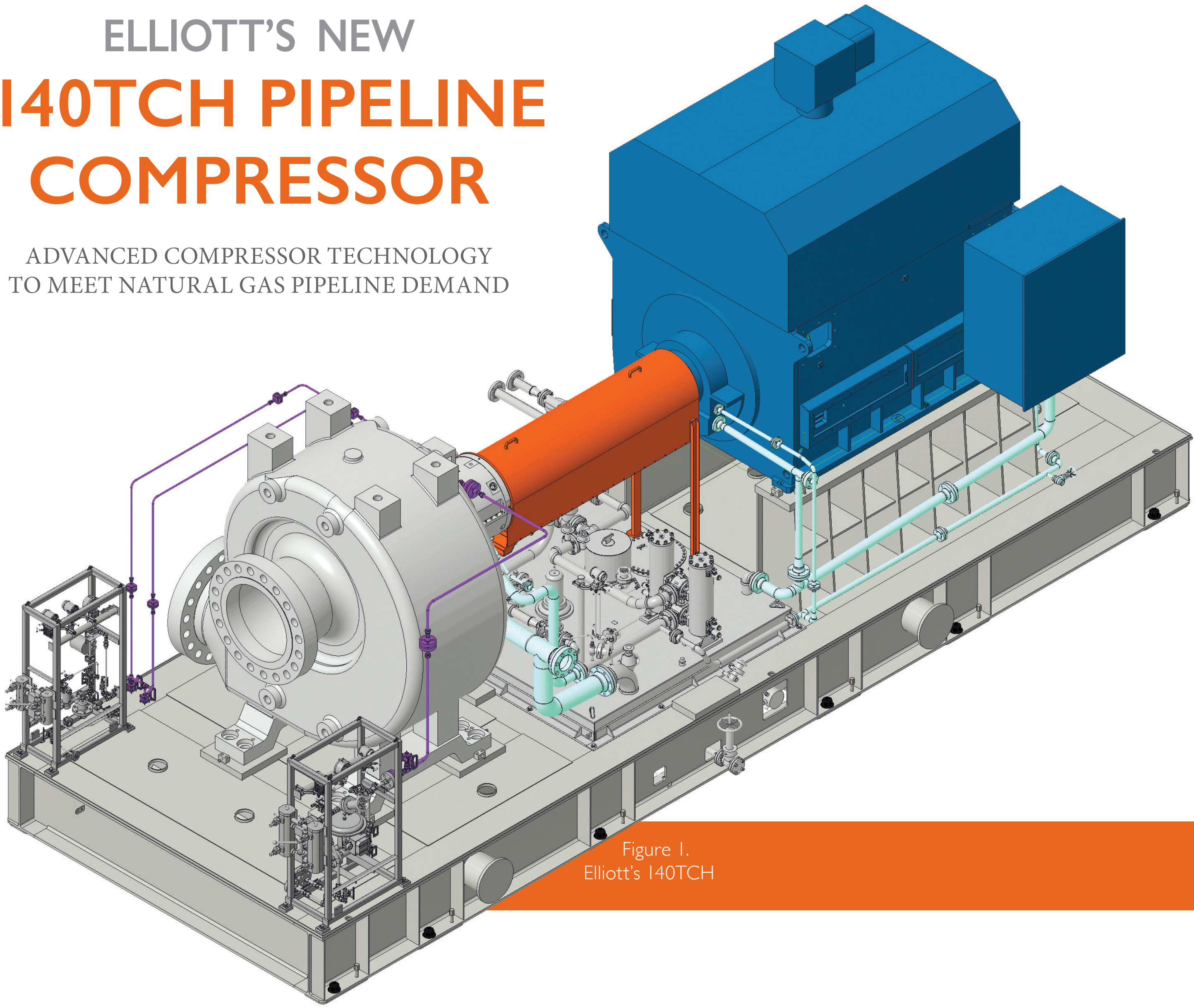

Figure 1.
Elliott's 140TCH

BY KLAUS BRUN AND TODD OMATICK

Compressors are installed in natural gas pipelines to inject gas into the pipeline at its operating pressure and then recompress the gas at certain distances along the pipeline to compensate for its viscous pressure drop. Typical pipeline operating pressures range from several hundred psi to about 1500 psi (103 bar) for standard pipe diameters, which range from a few inches to greater than 60 in. (1524 mm). In the United States alone, there are currently more than 7000 compressors installed in natural gas pipeline compression services in more than 2.6 million miles (4.1 million km) of pipelines. Approximately 25% of these compressors are old, low-speed, integral reciprocating machines that were originally installed between 1940 and 1970, making them technically outdated and mostly obsolete.

Growing demands for natural gas driven by increasing liquefied natural gas (LNG) exports, new/refueled fossil power plants, and increasing domestic consumption, have triggered the need to rapidly increase the North American pipeline compression capacity, both through the installation of new units and the replacement of older, low-power units with modern, higher-power units. At the same time, environmental regulations require the reduction of carbon emissions and gas leakage from pipeline operations, which has resulted in the preferred installation of electric motors over gas engines or turbines as pipeline compressor drivers.

Most centrifugal compressors currently being installed in pipelines were originally derived from process gas, barrel beam-style compressors. For this design, a long, multistage impeller shaft is mounted on bearings and sealed at both ends of the casing, and a balance piston and thrust bearing are used to limit axial movement of the shaft. This design evolved from classical refrigeration, refinery, and chemical process compressors that were originally intended to handle high-pressure ratios and a wide range of different gases at high pressures.

However, this design style is suboptimal for basic pipeline service where the pressure ratios are relatively low and the gas composition is fairly constant, but the operating conditions are highly variable and the compressor must operate for long periods without scheduled or forced outages. Furthermore, because pipeline operators traditionally prefer to use gas turbine drivers, most current pipeline compressor designs are speed-matched to provide optimal performance at high, gas turbine speeds rather than at the lower speeds of electrical motors. Driving centrifugal compressors with electric motors requires the use of a gearbox in most pipeline applications.

Elliott's new 140TCH pipeline compressor addresses some of these shortcomings with features that were specifically designed for natural gas pipeline service. It is also designed to minimize component count (Figure 1).

Elliott's 140TCH is a single- or dual-stage, overhung design with an axial inlet that is electric motor driven without a gearbox (Figure 2). This design approach results in higher efficiency, reduced leakage from a single, dry gas seal, and the avoidance of a balance piston. The 140TCH comes with a direct connect, variable frequency drive (VFD) motor and a standard footprint, in addition to custom aerodynamics for optimum efficiency and extended operating time between scheduled overhauls. The gearless configuration provides a smaller footprint, reduced lube oil requirements, and higher net efficiency. The high-speed, VFD-powered motor significantly reduces carbon dioxide (CO_2) and NO_x emissions as compared to a gas turbine driver. The VFD addresses power-grid issues and allows for adjustable operation to match load/capacity requirements. The pipeline compressor's single-lift plug-and-play design includes auxiliaries such as lube oil, a buffer gas panel, and integrated, customized controls. Piping and wiring are included on the skid. The Elliott 140TCH pipeline compressor is available from 10,000 to 42,000 hp (7460 to 31,332 kW) sizes to the full range of gas transport applications.

The 140TCH is designed to handle most modern, mid-sized, and large pipeline compression applications. The impeller aerodynamics are based on Elliott's EDGE technology. With the axial inlet and flexible or customizable aerodynamic design, efficiencies of greater than 85% can be obtained. The direct drive compressor, with a variable speed electric motor, provides a wide operating range including efficient turndown operation. With three standard frame sizes, 15 MW, 25 MW, and 35 MW, the centrifugal compressor is designed for applications up to 7000 MMscf/d (198×10^6 m^3/d) with a pressure ratio ranging from 1.15 to 1.8.

The machine design philosophy allows for installation with a standardized package, an axial inlet, and selectable discharge for right or left piping configurations. The package includes an integral lube system for the compressor and motor, a simplified buffer or seal gas panel (the compressor only has one seal), an on-skid control system, and all compressor piping and wiring included on a single-lift skid for reduced footprint and weight. The compressor internals are contained in an inner-barrel design and can be removed from the driver side. This allows for easy maintenance and removal of the compressor internals without the need to move any piping. The removable barrel also allows for quick and easy installation of spare bundles or compressor restaging to change aero components as needed (Figure 3).

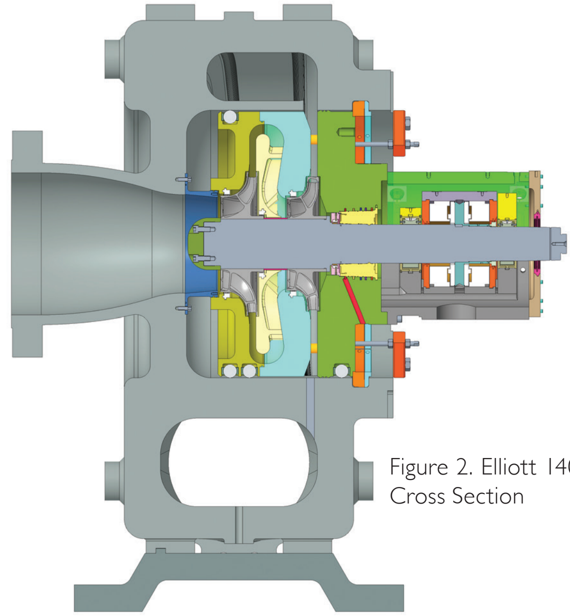

Figure 2. Elliott 140TCH Cross Section

PIPELINE COMPRESSION BACKGROUND

In the oil and gas industry, compressors are used for natural gas gathering, transport, processing, storage, and distribution. The United States has approximately 1700 midstream natural gas pipeline compressor stations, with a total of 7000+ compressors. The United States also has approximately 13,000 to 15,000 smaller compressors in upstream services, and 2000 to 3000 compressors in downstream oil and gas and LNG applications. An estimate from the US Department of Energy indicates that 1% to 1.5% of US natural gas is used by oil and gas compressors for consumption and leakage. The average age of US pipeline compressors is between 30 to 35 years, and industry estimates indicate that about 5 million hp (3.7 million kW) of currently installed US compressors must be replaced within the next 10 years.

The pipeline transport compression industry in the United States started in the early twentieth century with the introduction of slow, horizontal compressors (Figure 4), followed by low-speed integral, high-speed separable, and centrifugal compressors (both driven by gas turbines and electric motors). Horizontal reciprocating compressors were the original pipeline, prime-mover technology first installed in the United States in the 1930s. They used internal combustion, spark-ignited, four-cylinder engines running at 125 rpm with power cylinders that are horizontally opposed. Over the years, most of these units have been replaced with integral compressors, but some remain in operation on US pipelines in the northeast.

Later, in the late 1940s, gas integral reciprocating compressors were introduced to pipeline compression service. They are internal combustion, spark-ignited engine drivers with an integral reciprocating compressor. Here, the engine and compressor share the same crankshaft. The majority of these units were installed from 1950 to 1970, and these compressors are still the workhorses in the pipeline industry. Integral compressor units are either two- or four-cycle and are typically supercharged with power ranges between 600 to 17,000 hp (447 to 12,682 kW).

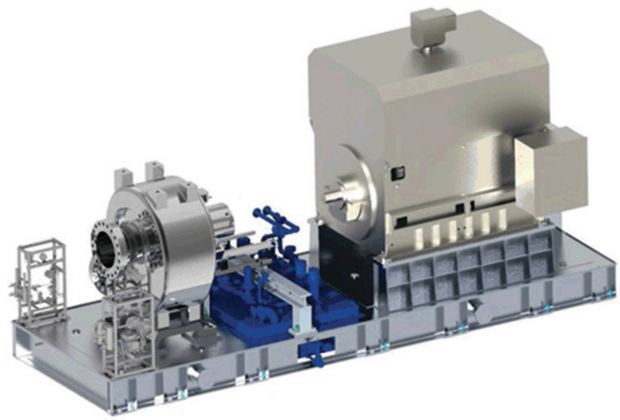

Figure 3. Elliott 140TCH Package And Maintenance Access

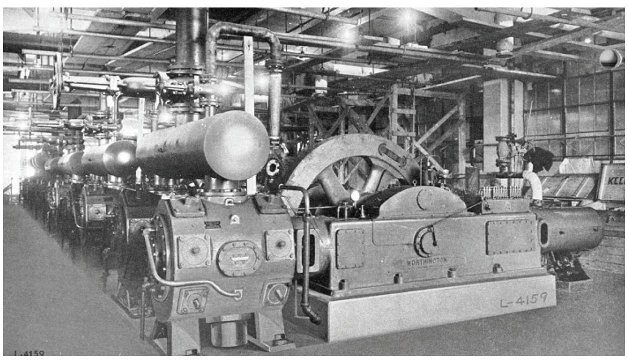

Figure 4. 1930s Horizontal Reciprocating Pipeline Compressor

They tend to be massive in size, have complex auxiliary systems, and are costly to operate. However, they have excellent efficiencies.

Gas-separable reciprocating compressors were introduced in the late 1960s and are currently still a major market player. The engine and compressor have individual crankshafts and are coupled as separate devices on a unitized skid. They operate between 350 and 2000 rpm with compression power up to 6000 hp (4476 kW). They tend to be lower in efficiency than integral reciprocating compressors but are significantly lower in first cost. Gas turbine-driven centrifugal compressors have been available since the 1970s and quickly became the prime mover of choice for most elevated power mainline applications. They tend to be more reliable than internal combustion engines and have very low maintenance costs, but their efficiency tends to be lower than many engine-driven compressors. Their first cost on a per horsepower basis is also significantly higher. Gas turbine units are normally used for applications between 7000 and 30,000 hp (5222 and 22,380 kW).

Electric motor-driven centrifugal compressors have been available for pipeline compression since the 1960s, but they were originally neglected by the industry because of the need to install additional electrical infrastructure on the pipeline. However, due to stricter environmental compliance regulations, they have become more popular over the last 15 years and now represent approximately 50% of all new, installed mainline pipeline compression equipment. This trend is continuing with an increased focus by the pipeline industry to reduce greenhouse gases, CO_2, and methane emissions point sources.

Electric motor-driven centrifugal compressors are available from low, single-digit power to well above 100,000 hp (74,600 kW) applications. There are several technical options to electrically drive a centrifugal compressor for pipeline service. These include fixed speed, variable speed using a VFD, variable speed using a hydrodynamic coupling, direct drive, and indirect drive using a gearbox. Since pipeline service by nature is highly variable in throughput, variable-speed solutions are preferred over fixed-speed drivers to avoid the need to recycle gas and to maintain a high efficiency over a wide operating range. Also, gearboxes add complexity and cost to the design while reducing reliability. However, since many centrifugal compressors designed for pipeline service were speed-matched to be driven by gas turbines, they usually require a gearbox when driven by a conventional electric motor. This is a design decision that can be avoided if a centrifugal compressor is designed from its outset for a lower speed driver, such as a synchronous or induction electric motor.

To meet the demand of new compression for the replacement of old legacy compressors and the increased power demand for natural gas, Elliott has introduced the 140TCH electric motor-driven pipeline compressor.

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