EMD Capacity Control Options
Centrifugal Compression

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INTRODUCTION

Electric Motor Driven Gas Compressor Stations have become the default recommendation when planning a new or expanded station. This recommendation is to encourage control of carbon emissions in an "Environmentally Sensitive" area. The industry has turned to Electric Motor Drive (EMD) Compression to fill the gap while maintaining project goals.

There is generally no financial advantage of a fuel switch to electricity other than engine emissions and maintenance costs as electricity is generally more expensive than gas as a fuel source.. Break-even analysis for the different fuel sources is not the prime consideration to determine basic compression driver configuration.

EMD facilities offer operational advantages of enhanced reliability, reduced maintenance costs and equipment longevity. A typical well designed electric motor is replaced every 20 to 30 years whereas a typical natural gas-fired turbine requires a major overhaul every 30,000 to 40,000 running hours (4 to 6 years) and an engine has a minor overhaul every 3,000 to 5,000 running hours (6 months to 2 years).

EMD CAPACITY CONTROL OPTIONS

This document provides a high level view of the design options for controlling and operating an EMD compressor and the design considerations to choosing the method.

Starting Method

Across the line starting is the simplest and best method for reliability and longevity of the electrical equipment. Costs for special electrical, electronic, or mechanical start systems and complexity of the design is avoided.

There are different methods of starting an electric motor including capacitive, reduced voltage, electronic soft-start and VFD. Older technologies include the pony motor assist start which uses a smaller motor, (typically rated at 10% of main motor rating) to accelerate the unloaded main motor to synchronous speed.

Equipment Limitations

Reciprocating compression is typically limited to 10,000 Hp due to compressor frame limitations and therefore the speed control is predominately accomplished by VFD; Centrifugal compression horsepower rating is limited only by operating and turndown limitations of the equipment with a practical limit in the 40,000 Hp range for a gas pipeline. Hydrodynamic drives are available from 5,000 Hp to 50,000Hp. Air cooled VFD Drives are available from fractional Hp to 10,000 Hp; liquid cooled VFD Drives available to 35,000 Hp as a single channel.

Speed Control Equipment Selection Option

Centrifugal gas compressors rely on speed changes for capacity control and therefore a method of controlling compressor speed is required. Speed control is accomplished by either a VFD (variable frequency drive) with a speed increasing gear which varies the motor speed by varying the input frequency or a hydrodynamic gear which acts like a car (CVT) transmission adjusting the compressor speed.

VFD Efficiencies and Advantages

VFD Start/Control is used almost exclusively on compression units that are 1,200 Hp and smaller. Larger VFD frames are available and are competitive with other methods of starting and control. VFDs smaller than 5,000 Hp are air cooled. Generally, VFDs larger than 10,000 Hp are water cooled. Air cooled VFDs require a cooling method for the electronic gear. Electronics cooling is typically handled by HVAC of the enclosure utilizing approximately 4% of the energy costs.

As electronic switchgear, the units are subject to obsolesce after several years based on improvements in the topology. A speed increasing gear is typically required for centrifugal compression units to match compressor impeller speeds. New high speed (supersynchronous) motors are being introduced into compressor service to avoid the need for a speed increasing gear and the resulting efficiency loss. The efficiency of a VFD train typically equates to 95% across the speed range including the isolation transformer, VFD converter sections, and the fixed gear box.

At turndown speeds, the VFD maintains near constant efficiency. Care in the motor selection for use with the VFD needs to include auxiliary motor cooling and torque availability at reduced motor speeds. A VFD can start a motor with essentially no electrical in-rush above operating conditions.

The power components of the VFD are more susceptible to power fluctuations. During periods of incoming power instability, of typically 2% the VFD may disengage and shutdown the system power.

Space and real estate requirements for a VFD solution includes additional room for isolation transformer and the VFD Power modules.

VFD Cabinets (small to medium BHP) for placement inside Control Building

Hydrodynamic Drive Efficiencies and Advantages

Hydrodynamic drive trains are available for horsepower blocks in excess of 5,000 Hp, typically for centrifugal compression, at an economical cost. These drive trains require additional space inside the compressor train line-up and a larger lube oil cooling system. System efficiencies are comparable to the VFD drives at full speed that include the speed increasing gear. The hydrodynamic drive has fewer operational issues and higher reliability.

At turndown speeds, the efficiency of the drive train decreases as the distance from the design point increases. Motor selection for use with the hydrodynamic gear is less critical as the motor runs at 'full" speed" during operation and rotor heating is infrequent. Starting a large motor will include additional review and equipment in coordination with the power supply and in-rush allowance by the power company.

The power components of the hydrodynamic drive as less affected by minor power fluctuations due to the mass of the spinning components and ability of the motor to adjust to a 10% voltage fluctuation.

EMD Compressor Train utilizing Voith Hydrodynamic Gearbox

Reciprocating Compressor with EMD

Summary Table

The table below summarizes the considerations for speed control.

Speed Control Considerations		Drive Train Type			
		VFD			Hydrodynamic Drive
		Air Cooled	Air or Water Cooled	Water Cooled	
Compressor Type	Horsepower Range	Up to 5,000 Hp	5,000 to 10,000 Hp	Over 10,000 Hp	
Reciprocating	Up to 5,000 Hp	Applicable	N/A	N/A	Not economical
	5,000 Hp to 10,000 Hp	N/A	Applicable	N/A	Applicable but not typical
Centrifugal	Up to 5,000 Hp	Applicable	N/A	N/A	Not economical
	5,000 Hp to 10,000 Hp	N/A	Applicable	N/A	Applicable
	10,000 Hp to 40,000 Hp	N/A	N/A	Applicable	Applicable

UPI CAPABILITIES

UPI offers a full complement of services for pipelines and related facilities that includes but is not limited to conceptual design, FEED, project development, Total Installed Cost (TIC) estimates to assist with funding, detailed design, and EPC/EPCM. Services include project management, engineering and design services, procurement services, subcontractor management, survey, laser scanning, construction management, inspection, Mobile Inspection Platform (MIP), systems integration, automation, process controls, as-built documentation, commissioning, and decommissioning.

UPI has a rich heritage of project experience for pipelines and related facilities. UPI has provided professional services (engineering, surveying, and construction management) for thousands of miles of pipeline and installed millions of horsepower of pumps and compressors.

A representative list of UPI's projects includes:

Dominion Natural Gas - Pleasant Valley Projects

UPI provided detailed design services to expand Dominion's Pleasant Valley Compressor station to service the Cove Point Liquefaction, Keys and CPV projects. The total installed Hp was 110,000 containing both high speed reciprocating and centrifugal compressors. All units were electric motor drive requiring upgrades to medium and high voltage service for the station. The project included expansion of the existing building and an addition of a new compressor building to house five new compressors at the station. The compressor station expansion also included piping and equipment upgrades to the Pleasant Valley meter and regulator station.

FPL Port Everglades

UPI provided FEED, detail design, and procurement services to increase delivery pressure from 50 and 250 psig to 250 and 650 psig respectively and shift an additional 25 MMBTU/D. The scope included two 22,000 Hp centrifugal compressors, gas coolers, lube oil coolers, gas scrubbers auxiliary building, suction and discharge piping, switchgear, other associated equipment, and a stopple bypass for the 24-inch mainline.

Net Mexico Agua Dulce Compressor Station

UPI provided FEED, detailed design, survey, procurement, and construction management services for 3 compressor stations and 120 miles for 42-inch and 48-inch natural gas pipeline. The 3 compressor stations included one with four 25,000 Hp electric drive centrifugal compressors by Solar, one with 2 engine driven reciprocating compressors, and the third has 2 engine driven reciprocating compressors. UPI managed ROW and Environmental subcontractors.

Florida Gas Transmission - Port Everglades Station 21.5

UPI provided FEED, detailed design, and procurement services to Florida Gas Transmission for the addition of two 15,000 HP EMD Centrifugal compressor units. The scope was to increase the delivery pressure from 50 and 250 psig to 250 and 650 psig respectively and shift an additional 25 MMBTU/d to the FP&L Port Everglades meter and regulator station while maintaining all current contractual requirements.

Florida Gas Transmission - Cape Canaveral - Station 32

UPI provided FEED, detailed design and procurement services for installation of Compressor Station 32 (CS 32) consisting of two (2) 15,000 electric drive centrifugal units with Voith VSD. The scope included suction and discharge piping, FGT's portion of required switchgear and installation of pulsation bottles, gas cooler and the relocation of station blow stacks to CS 18. UPI prepared the Class III Cost Estimate during FEED.

Florida Gas Transmission - Phase VIII Expansion - Compressor Stations 11, 13, 15, 27

UPI provided detailed design, FERC filling, construction management, inspection services, and as-built drawings. The facility scope included 10 compressor stations with 11 compressor units for a total of 207,600 Hp from Mississippi to Florida. EMD with Vorecon hydrodynamic drives were installed at 4 stations totaling 88,000 Hp. The pipeline scope included 240 miles of 24-inch, 30-inch, and 36-inch pipeline.

Cypress Compressor Station Trunkline Gas Company

UPI provided detailed design, procurement, construction, and commissioning services for the installation of a 7,000 Hp EMD compressor. The scope included electrical substation, various vessels, high pressure gas yard piping, unit blowdown piping, and control systems.

Transwestern - Roswell Station

UPI provided detailed design and procurement services for the replacement of two LSV Engines with two 5,000 Hp EMD compressors in the existing building and ancillary equipment.

Bammel Storage Facility

UPI provided detailed design, survey, and procurement services for the installation of 7 EMD two-stage natural gas compressors totaling 49,000 Hp. Operating pressures range from 550 and 750 psig for suction and 1,300 to 2,400 psig for discharge. The facility uses 6.9 kV variable frequency drives and transferred to "across the line" at synchronous speed. Two VFDs were also installed. The station has dual 138 kV power feeders and auto-transfers in the event of a highline fault.

Transwestern Pipeline Company - Gallup Compressor Station - VFD

UPI provided detailed design, procurement, and project management services for the construction of a grassroots EMD compressor station comprised of a 12,000 Hp electric motor/VFD with a Rolls-Royce (now Siemens) compressor and ancillary equipment.

CLOSING

UPI looks forward to talking with you about how we can help you with your project.