

(Left) The different lubrication systems that service a reciprocating compressor are described during a training program. The high-pressure low-volume auxiliary lubrication system that services rod packing and cylinder piston rings is detailed, as well as the high-volume low-pressure main system that lubricates crankshafts, connecting rods and crossheads. (Right) This chart explains how compressor valves function. Emphasis is placed on plate travel and the requirement that valve springs must match the working pressure of the gas to provide proper cushioning. Also discussed is the need for spring tension to match the valves' travel velocity to prevent the destructive effect of valve plate impact.

FIELD TRAINING FOR GAS COMPRESSION OPERATORS

Industrious Solutions Works with Producers to Maximize Natural Gas Production by Delivering Specialized Technical Training Programs for Gas Compressor Packages

By Neil Purslow

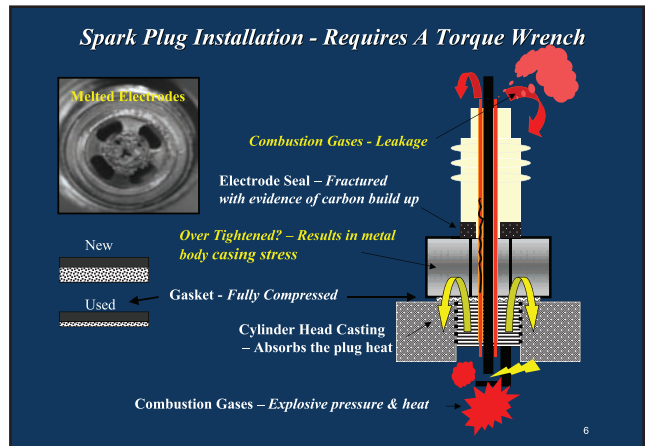
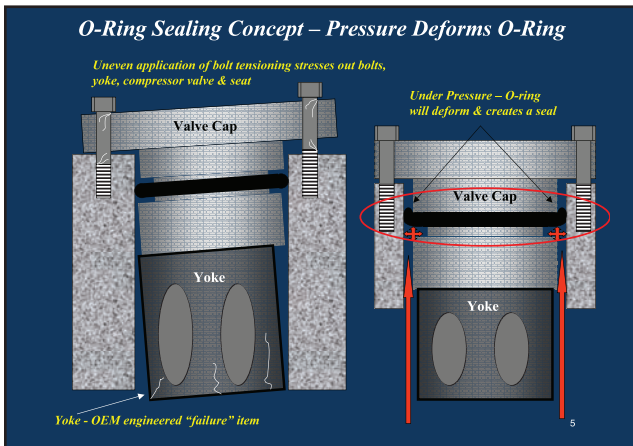
Training has been in Bill Gibb's blood forever. Gibb, managing director of Industrious Solutions Inc. of Calgary, Alberta, Canada, said, "I've been involved in training in one capacity or another since I entered the workforce. I've seen and experienced firsthand what works and what doesn't work. I knew early on that I had a natural ability to help others, and began planning for the day when I would have my own company that would specialize in delivering effective technical and personal development training."

That day came in July 2005 when he launched Industrious Solutions.

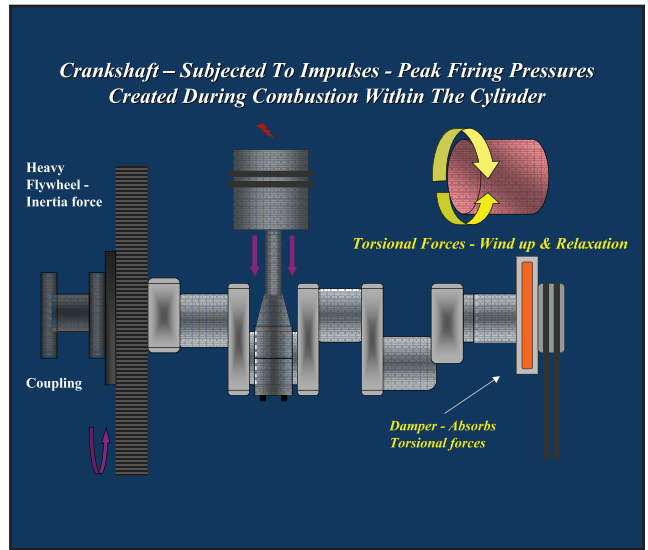
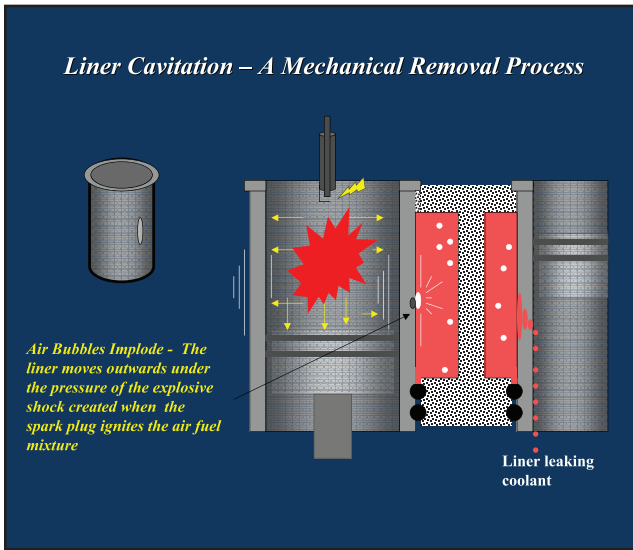
(Talk about advanced planning — the name of the company was selected in 1990 and Gibb patiently waited 15 years for the company to launch.) Gibb is a heavy-duty mechanic by trade and an MBA graduate, who has spent about 25 years fabricating, maintaining, servicing and selling natural gas compression packages. Gibb has also instructed at ENFORM and with the University of Calgary's Faculty of Continuing Education. He is also a strong advocate for lifelong learning.

"Many technical training programs consist of data dumps," said Gibb, "mostly from vendors who would rather

be doing anything but train clients, and from personnel who have no formal instruction in how to teach adult learners. Technical information is passed on at these sessions, but little practical application is provided. Most operators are visual learners. They need to see diagrams and images that take the technical information and relate it to the equipment they know. They also need to understand how to handle problems, troubleshoot operations and communicate with mechanics, engineers and other service providers. There is a definite need for focused field training to address these issues."



(Left) Internal stresses are created when manufacturers' compressor valve cap bolting procedures are not followed. The design features of the valve cap O-ring are illustrated to promote an understanding of the sealing effect and principles of O-ring deformation. The rationale for only using O-ring seals once is also discussed. (Right) This chart explains the unique and critical design features of a spark plug. It also shows the need to follow manufacturers' directions regarding torquing procedures and the restoration of the heat transfer pathway through the use of new gaskets each time a plug is removed and reinstalled.



(Left) This illustration explains how cavitation is caused and its damaging effects. Cavitation is the undesirable repetitive mechanical erosion that results from air bubbles entering a cooling system. The result is coolant entering the crankcase and contaminating the engine's lubrication oil. **(Right)** This chart explains the naturally occurring torsional effects that occur when a spark plug is fired. The rapid expansion of the combustion gases creates a repetitive winding up and relaxation effect within the crankshaft, which is managed through harmonic dampers.

The goal of Industrious Solutions is to deliver relevant technical training that enables operators to operate gas compression equipment safely and efficiently, Gibb said. The company's programs enhance the operators' skill set in five areas: observation, troubleshooting, theoretical understanding, equipment utilization and equipment ownership. By increasing awareness in these areas, operators gain confidence in executing their responsibilities, and with a better understanding of the equipment and processes, their sense of ownership in the facilities and operations increases.

Gibb delivers his training programs through a series of modules. Module topics include engines, electric motors, reciprocating and screw compressors, coolers, foundation issues, vibration, pulsation, compressor suction and discharge valves, and how gas reacts when it is compressed. Each module topic is available in three levels, depending on the depth required.

Because research indicates that 75% of people are visual learners, 15% learn by listening and the remainder comprehends by reading, Gibb spent considerable time developing the visuals for his courses. Charts and images include the use of brilliant colors and hand-developed imagery that reduces the amount of text required. These factors contribute to the trainees' ability to retain the concepts they learn, Gibb said.

Before a training program is delivered, Gibb performs a needs assessment study to gain an understanding of the skills shortage. The assessment is performed either on-site or through

a telephone interview process. Once he has compiled the results, he develops a site-specific program to address the additional skills required at the gas processing facility. After the proposal is approved, he prepares a tailored program using previously created visuals and new imagery.

The scope of the program varies with each delivery based on the needs and abilities of the participants. Additional emphasis may be placed on certain modules, and the delivery may switch between levels depending upon the audience. Other concepts are also addressed in the programs, such as heat and how it affects the various stages of compression and what it does to rings, lubrication oil and equipment components on a compressor package.

Gibb delivers training programs on- or off-site in settings that are conducive to learning. On occasion, field lunchrooms have been transformed into classrooms. Industrious Solutions provides the necessary audio-visual equipment required to deliver the programs anywhere.

At the start of each class, Gibb has the participants sign in and provide information about their background and work experience. This information enables him to further customize the program to the particular group.

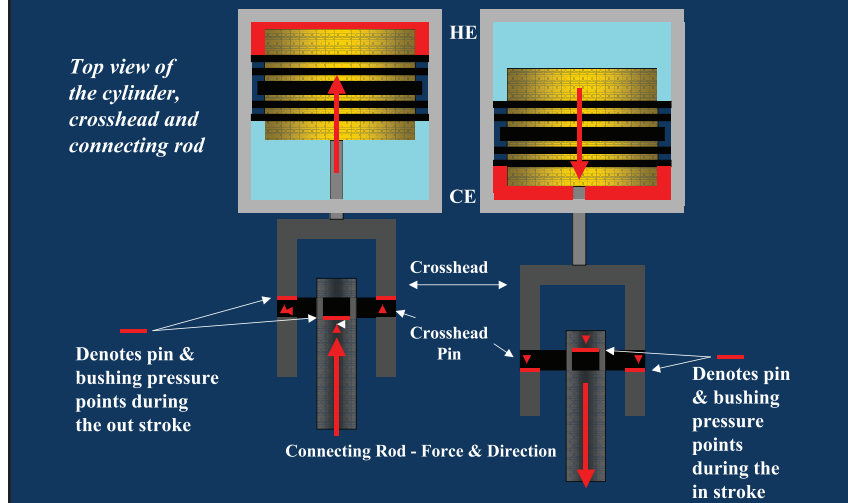
"The real value in this type of training is relating the theory to real-life situations in plain English," explained Gibb. "I am in a unique position because I have commissioned and maintained this equipment and can relate to what the operators are experiencing. As well, I can explain in simple terms how the equipment

functions and what to do to fix and maintain it." As an example, a reciprocating compressor is dependent upon the operator having a clear understanding of the forces at work while the gas is being compressed. Compressor rod loading, crosshead pin reversal and the effect that the gas re-expansion event has on the operation of the suction and discharge valves are all explained in easy-to-understand terms.

Gibb also provides insights about why certain procedures should be followed as recommended by equipment manufacturers. For instance, the importance of using a torque wrench when installing spark plugs on an engine is stressed because over-tightening causes small hydraulic fractures inside the plug and unduly compresses the gasket. This results in voltage leaks and reduced heat transfer. Often participants have experienced ignition system problems that affect an engine's performance, but do not know why it happened. Many spark plug failures are the result of poor installation practices, he said.

Industrious Solutions also performs root cause failure analyses. The process and outcomes are shared with participants to help them troubleshoot their own issues and avoid similar failures. One such example is the long-term effect of using air impact tools on compressor valve cap retaining bolts. Often in this situation when the bolts were tapped on a flat surface, fine metal casting granules can be observed. Observations revealed that each time the hardened bolts were removed from the softer casting

Crosshead / Connecting Rod – Bushing & Pin Wear Patterns



This illustration explains crosshead pin reversal in a reciprocating gas compressor and identifies wear patterns that develop over the service life of the components.

using high-speed air impact tools, a small amount of metal from the threads was removed. This problem becomes more pronounced as the equipment ages. Operators are instructed to follow the manufacturer's maintenance instructions, use the appropriate torque wrenches and limit the use of air impact tools in critical fastening situations.

"We have had excellent success with this approach of using real-life examples in the training process," said Gibb. "The feedback from op-

erators has been positive and they take ownership of the equipment. We provide training to engineers, management and administration — to anyone connected to the natural gas industry. We also offer personal and career development courses, such as effective communications, conflict resolution and goal-setting. All are designed to help operations personnel achieve their career aspirations."

Along with delivering training programs and root cause failure



Industrious Solutions Inc. specializes in training on all aspects of natural gas compression. Bill Gibb works directly with producers to maximize their gas production by providing customized on-site technical and career development training programs.

analysis services, Industrious Solutions also evaluates maintenance programs and provides business development consulting services. Gibb and his team of gas compression experts provide direct industry experience to gas producers throughout Canada. ©

COURSE OUTLINE

This course outline is used to deliver a typical Level 2 training program to natural gas operations personnel. The program is delivered on-site over one or two days, depending upon the level of detail required by the participants.

Level 2 — Natural Gas Engine and Compressor Package Training

Listing of Program Topics

Opening — Introduction

Compressor Drivers

- Driver options — engine or electric motor.
- Defining high performance — industrial use of equipment.
- Understanding the contributing factors that cause pre-ignition and detonation — critical intake air temperature design.
- Fuel systems — component identification, air/fuel ratios and troubleshooting tips.
- Turbochargers — operation and ad-

vantages over naturally aspirated engines.

- Engine lubrication systems — function and components.
- Cooling systems — main, auxiliary, types of coolers and troubleshooting.
- Cooling system fans—prevention of overloading and overcooling, and troubleshooting.
- Understanding cooling systems — preventing cavitation and troubleshooting.
- Managing engine crankshaft torsional effects — engine loading and fan drives.
- Understanding how crankshaft failures can be prevented.
- Ignition systems — understanding the critical ignition system components.

Natural Gas Screw Compressors

- Screw compressor loading and unloading.
- Lubrication — flood screw design.
- Filtration — inlet and final discharge.

Natural Gas Reciprocating Compressors

- Gas compressor selection process — performance software exercise.
- Compressor valves — suction and discharge.
- Piston rings — sealing.
- Rod packing — function.
- Packing vent and drain system options — examples and function.
- Managing mechanical forces.
- Controlling cylinder capacity.
- Pressure volume — the effect on valve operation.
- Compressor rod loading — limitations and protection.
- Crosshead pin reversal — preventing a failure and examples of operating scenario.
- Compressor lubrication systems — main and auxiliary.
- Component identification — function and troubleshooting tips.
- Compressor fasteners — critical service cyclical effects.

Question and Answer Period