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Challenges and Opportunities in the HVAC&R Business Today (keynote speech from 1994 International Compressor Engineering and Refrigeration Conferences)

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CHALLENGES AND OPPORTUNITIES IN THE HVAC&R BUSINESS TODAY

Good morning ladies and gentlemen. It is indeed an honor to be asked to address this conference which is the leading compressor symposium in the world. You have had some impressive speakers in the past. I think it is always important that the speaker finish his talk before the audience does! As I begin a talk like this I am always reminded of the Oscar Wilde quote, "It is better to have a regular income than to be a fascinating person."

Today, I would like to address three phases of our industry:

- Business and environmental market forces.

- Challenges and questions facing manufacturers and designers of systems.

- Where engineering is today on compressors.

Globally, we participate in an industry (HVAC&R--Heating, Ventilating, Air Conditioning and Refrigeration) that is valued at approximately $40 billion dollars. Traditionally, our industry has grown at approximately 4-5% compound annual growth rate. Recently, the rate of growth has increased due to several market forces--they are:

- The CFC refrigerant changeouts related to ozone depletion.

- An increase in the aftermarket due to normal aging of commercial systems, 50% of commercial buildings in the U.S. are more than 20 years old. The normal life expectancy of commercial systems is 20-30 years depending on many factors.

- A change in the concept and application of A/C and refrigeration systems. Fifty to sixty years ago our industry had been formed, but was still in its infancy.

- Air conditioners were almost unheard of in homes and automobiles.

- Much of food and beverage production, storage and distribution relied on cooling supplied by ice plants; synthetic fabrics from petroleum derivatives were in their infancy.

- There was no electronic or computer industry.

- Dramatic changes in technology and increases in population have turned our industry from a luxury to an absolute necessity. Today we could not feed or clothe the world's population or support the global standard of living most of us enjoy without our product.

- Demand side management programs continue to gain popularity. These programs focus considerable effort to reduce dependency of electrical power usage. Utility companies are looking at technologies such as thermal storage, gas absorption systems and natural gas driven systems as well as looking more closely at rebate programs based on-peak load performance of equipment.

Small wonder the rate of growth is increasing and predictably these secular trends will continue.

Additionally, cyclical forces naturally affect the rate of growth for our industry. We believe the U.S. economy has rebounded, Europe is showing positive signs and our industry is poised to address the pending recovery in these market places.

Latin America and Pacific Rim nations continue to show higher than average growth rates as these economies expand.

The globalization of our industry is evident in a number of areas. These include:

- Communications - the ability to effectively communicate with customers, suppliers, and peers on a worldwide basis.

- Product development and product redesign to address specific market needs and flexibility in meeting specific customer requirements.

- Consolidation of players in the HVAC&R industry as we realize the benefits of the synergistic effects of these consolidations.

Most estimates are in the 6-8 percent CGR range when the effects of the CFC replacements are behind us. It is difficult to predict how long the replacement of CFC equipment will take. The momentum is picking up, but still not near the pace required to assure an orderly phase out of CFC's. There is still a large number of users who have not begun to address the problem.

While the growth rate is somewhat predictable, the challenges we will face as an industry are not. Remember, the Montreal Protocol was signed in September 1987. At that time, 24 countries participated. As of June 1994, there are 135 countries as signatories. How many of us would have predicted in the early 80's that environmental concerns would become one of the major market forces in our industry?

Not many, we all had our heads pointed in a different direction -- energy shortages -- how quickly they disappeared -- as more oil reserves were found, usage was reduced -- alternate sources were employed. Today the market force relating to improved efficiencies is environmental -- energy conservation, not driven by shortages of oil and gas reserves, but driven by environmental concerns -- ozone depletion -- global warming -- air quality and -- acid rain to name a few.

There are several other factors that will have a somewhat predictable effect on our industry in the coming years:

- Indoor air quality.

- Noise pollution.

- Space considerations (equipment size and weight).

- Increasing safety concerns - for refrigeration gases and equipment inside building structures.

Again to name a few.

We can deal with these issues as an industry and in many cases, they are now being addressed. We can only hope we don't get many more "ozone holes" to deal with in the next few years. The unpredictable situations really cause disruption; however, the issue is being handled effectively on a global basis by our industry.

Our industry is used to taking a leadership position as evidenced by the fact we have demonstrated leadership in many areas, such as:

- The energy reduction effort.
- Protecting the atmosphere.
- Noise reduction.

It is interesting to note that Arnold Braswell, retired president of ARI, addressed this group in July of 1988, one year after the Montreal Protocol was signed. His talk was in many ways prophetic. In his closing, he left us with a list of six things to be accomplished as an industry resulting from the Montreal Protocol. They were:

1. Increase the usage of HCFC's as replacement refrigerants.
2. Expedite the research and testing of new alternate refrigerants. Industry-wide cooperation is important in this effort.
3. Reduce emissions of CFC's and improve conservation in all areas.
4. Expand equipment, techniques and facilities for reclaiming and recycling of contaminated refrigerants.
5. Quantify the size of task of refrigeration replacement on a global basis. This will be necessary to plan the production capacity necessary to accomplish the changeover without major shutdowns.
6. Global cooperation between manufacturers', industry associations and governments will be required to accomplish the entire program.

Based on where we are today, I would say Arnold was on the mark with his challenges and the industry gets a good report card on accomplishing the tasks.

CHALLENGES AND QUESTIONS FACING MANUFACTURERS AND DESIGNERS OF SYSTEMS

As we approach the second half of the 1990's, several challenges lay ahead:

- The energy efficiency of compressors and HVAC&R equipment must increase as rapidly as technology and economics allow. Improved efficiency is necessary to address global warming concerns and, in the U.S.A., to meet government energy efficiency regulations.
- Users will continue to expect HVAC&R equipment to be very reliable, delivering many years of efficient operation. Service costs are expected to be minor relative to life cycle costs, and service intervals are expected to be infrequent and predictable.
- HVAC&R systems must be designed so refrigerant emissions during operation and servicing are reduced to an insignificant amount.

- Increasing emphasis will be placed on quiet operation.
- As the decade ends, we may see greater interest in "recycling" of the components of HVAC&R systems to avoid the clutter of junkyards and landfills. This might require manufacturers or sellers to accept trade-ins of worn out equipment and to recover the materials for reuse in some form.

There also are significant questions remaining about which refrigerants will be the ones selected as the successors to R-22, R-502, and R-123 as phase-out dates become of concern to our customers. This prospect raises several questions:

- Will high-pressure refrigerants, relative to R-22, such as the R-32/125 azeotrope or carbon dioxide be selected for particular applications? If so, substantial redesign of compressors will be required to package higher power and accept higher structural loads in machines with smaller displacements than for R-22.
- Will zeotropic refrigerants be used widely? If so, vapor compression systems must include new design features - particularly in heat exchangers - to achieve high system efficiency despite lower refrigerant theoretical cycle efficiencies compared to R-22. Suction line/liquid line heat exchangers appear to offer cycle efficiency advantages for most of the HFC refrigerants.
- Is there a suitable refrigerant to succeed R-123 in low-pressure centrifugal chillers?
- Will HFC-134A survive in the long term in a world where environmental concerns seem to increase at a rate which outpaces the engineering community's efforts to respond with convincing logic? If HFC-134A is not a survivor, what about other HFC's and HFC mixtures?

Now let's address some items more specific to the compressor side of our business and the main topic of this symposium.

REVIEWING WHERE ENGINEERING IS TODAY ON CONVENTIONAL COMPRESSORS

Reciprocating Compressors

Recent developments have accomplished improvements in efficiency through novel valve and porting designs that reduce flow losses and heat transfer between suction and discharge flows. Tandem compressors are offered now as a low-cost way to obtain multiple capacities, improving part-load efficiencies in residential and commercial air conditioners and heat pumps. Further improvements will continue.

Rotary Compressors

The most common form of rotary compressors for refrigerators and low tonnage air conditioning units is the "rolling piston" compressor with a single sliding vane in the stationary housing. Recent designs have included machines of larger displacements and horizontal shafts. Tandem compressors are available for higher pressure ratio applications. Variable speed drives up to 120 Hz, have become common. Incremental design improvements continue to be made in oil management and reduction of friction losses. Noise and vibration reduction work also continues.

Scroll Compressors

Scroll compressor technology is in a stage of very active development, as measured by the approximately 60 new patents issued each year. New ways to improve efficiency through mechanical design, oil management improvements, machines for higher capacities, and variable speed versions are some of the active areas.

Screw Compressors

Twin-screw Lysholm type compressors are being applied more broadly in R-22 air conditioning systems as alternatives to reciprocating compressors. This has led to development by several manufacturers of comparatively low-cost semi-hermetic machines in the 30-100 ton range. These machines required the development of low-cost oil separators because they are oil flooded. Larger compressors also have become available for water chillers with either R-22 or R-134A as refrigerants. Future work is likely to address efficiency improvements and reduction of compressor noise. Variations in rotor geometry to improve noise and efficiency will continue to be developed.

Let's take a minute to review some of the unconventional compressors and cycles.

Stirling Systems

The Stirling cycle has been shown to have competitive COP's in low temperature refrigeration applications. At air conditioning temperature levels, the Rankine cycle (the conventional vapor compression cycle) is a better performer.

"Kinematic" Stirling compressors, with hermetic piston rods and highly loaded bearings and seals in the crankcase, have not been attractive for mass production. Seals remain a major problem. Therefore, "free piston" Stirling engine/compressor combinations have received the most development attention recently. This design eliminates the crankcase and has few moving parts. Oil-free operation in the compressor can eliminate some sealing concerns, but it is still important to minimize internal gas leakage in the gap between the displacer piston and the cylinder. Close manufacturing tolerances are required, leading to high costs. Bearing life and reliability have not been demonstrated in practical systems. Components such as engine heat exchangers and regenerators have not reached the levels of durability and performance needed.

Despite significant unsolved design problems and reduced performance in air conditioners, the Stirling cycle will continue to receive attention in some circles because it employs environmentally-attractive helium as the working fluid.

Carbon Dioxide Systems

Carbon dioxide is receiving renewed interest as a "natural refrigerant" for air conditioning applications, the condenser pressure is above the critical pressure for the refrigerant, so a gas cooler is used instead of a condenser. The system includes a receiver with the evaporator. A carbon dioxide system operates at much higher pressure levels than R-22 systems, but with much lower refrigerant flow rates per ton of cooling capacity. The pressure ratio across a carbon dioxide compressor is significantly lower than for R-22, which allows good compressor efficiencies to be achieved despite the high loads and small size. I don't believe any compressors are now available for air conditioning applications using carbon dioxide.

In summary, trends in vapor compression system design are driven by efforts to improve the energy efficiency of air conditioning and refrigeration equipment. This coupled with HFC mixtures as new refrigerants are causing manufacturers to explore a number of old and new variations on the vapor compression cycles such as:

- Counterflow heat exchangers to match the temperature glide characteristics of zeotropic HFC mixtures.
- Suction line/liquid line heat exchangers to obtain cycle efficiency improvements based on HFC thermal properties.
- Addition of energy recovery components, such as two-phase turbines, in place of the throttling expansion process in centrifugal chillers.
- Common use of subcoolers and enhanced heat transfer surfaces.
- Design to minimize the amount of charge in a system.
- Gas-fired equipment and cooling storage equipment to reduce peak electrical power usage.
- Variable speed or variable capacity compressors to increase seasonal energy efficiency of systems.

A full plate of opportunity for our industry.

These problems and opportunities that face the HVAC&R industry will impact all of us personally as well as those within our organizations. I firmly believe the rate of change we will see in our industry's future is a blessing for us all. Many of these changes benefit our environment and our customers. Certainly tomorrow's new technologies and applications will force us to think even more boldly about the solutions we offer. I personally gain greater satisfaction from participating in an industry such as ours because it is not hesitant or afraid of what lies ahead. The people in this room, and our colleagues who could not be here this day are the creators of change. To all of you I say thank you, and I hope your futures will be rewarding and satisfying.

I hope not many of you finished these remarks before I did. In general, once you get an executive of this industry cranked up, it's hard to turn him off.

I thank you again for having me, it's been a pleasure.

We have some time left for questions.

Appendix B

Additional papers from the 1996 International Refrigeration Conference at Purdue