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DESIGN CONSIDERATIONS FOR HIGH AMBIENT CONDITIONS

A compressor's ability to survive under adverse ambient conditions varies with both compressor and system design. The system designer must realize that a unit that might operate quite satisfactorily with a low failure rate under mild ambient conditions may be completely unsuitable for operation in an extreme environment, whether it might be in northern Canada or the Arabian desert. The heat pump failure fiasco in the United States in the late 1950's and early 1960's should serve as a chilling reminder of what can happen when a product is thrown into a market place without sufficient regard for its operating limitations.

With the increasing importance of the Mid-East and equatorial Africa in world air conditioning and refrigeration markets, any company exporting or designing air-cooled equipment for those areas should review their design standards to be sure they are adequate. In areas close to the equator, radiation from the sun's rays and reflection from a roof top or concrete can result in effective air temperatures entering an air-cooled condenser considerably in excess of the measured air temperature. Knowledgeable engineers with experience in the Mid-East feel that a unit to be safely applied without restriction in that area must be capable of continuous operation with entering air temperatures of 125°F.

Obviously the most critical area of unit design for high ambients is the condenser. The higher the condensing pressure for a given evaporator pressure, the higher the compression ratio and the more critical the discharge temperature. In general, for high ambient areas, Copeland would recommend an air to condensing temperature difference of 10°F for low temperature units, 15° to 20°F for medium temperature, and 20° to 25°F for high temperature. A direct air blast on the compressor will help in maintaining acceptable oil temperatures, and minimum superheat in the suction vapor entering the compressor is advisable. In critical applications it may be necessary to insulate the suction line.

Recent field investigation in the Middle East indicates two specific areas where system design may be improved to obtain better reliability.

Single phase motor failures appear to be closely related to starting difficulty under low voltage and high pressure differentials. It is recommended that supplementary start devices be applied with all single phase compressors. The solid state PTC devices now on the market offer a reasonable increase In starting torque with no penalty in electrical reliability.

On through-the-wall window air conditioners, units with side air inlets are extremely vulnerable to thick walls and sloppy installations. It would be our recommendation that all through-the-wall units intended for the Mid-East market be designed with both air inlet and discharge on the face of the unit to achieve better air flow over the condenser.

Users should not be expected to be compressor experts, but certainly system designers should have the engineering expertise and sophistication to evaluate alternate compressor designs with regard to durability and reliability. There are fundamental differences in design between a welded as opposed to an accessible hermetic compressor, differences which are reflected in both cost and performance. From an operating standpoint, the most significant difference is the ability of the compressor to reject heat to the surrounding air. An accessible hermetic compressor has the motor in direct physical contact with the compressor body, so heat conductivity to the external surface is highly efficient. Of even more importance, the compressor head where gas is discharged from the cylinder at its highest temperature is directly exposed to the ambient air. In contrast, on a welded compressor both the motor and the compressor head are totally surrounded by refrigerant vapor, there is very little direct metal to metal conduction to the outside shell, and the greatest proportion of the heat rejected goes directly into the refrigerant vapor.

In high ambient areas where effective heat rejection is critical for compressor survival, con-servative system design may be critical in the survival of any compressor, and certainly is far more critical with welded compressor design than with accessible-hermetic.

Users frequently ask for critical temperature limits in compressor application, with the optimistic hope that there is a magic black and white guideline that will insure satisfactory operation. As with most things in life there is no easy answer, since the time a compressor must operate at extreme stress conditions is of equal importance.

It might be helpful to visualize a compressor's life expectancy in terms of concentric circles, much like the life rings on a tree trunk. The center would be the most optimum operating conditions, normally the mid point of the compressor's design operating range. The outermost circle would represent the limit of the compressor's operation, which might be determined by marginal temperature, voltage, motor loading, or lubrication. Assume the compressor's life expectancy at the center to be 25 years, and at the limits to be 25 days. Operation at those limits for many hours might not be harmful if the majority of the operating hours were well within the limits of easier operating conditions. But under continuous or long term operating conditions, the compressor's life expectancy is going to be decreased as the operating limits are approached, and the design engineer who assumes the same life expectancy at the limits of compressor operation that might be expected in the center of the operating range is being unrealistic.

The most critical temperature conditions are probably not at maximum load, but at the higher compression ratios created by high condensing temperatures and low evaporating temperatures. For high ambient applications, operating tests should be run to evaluate the performance of the system at normal evaporating temperatures and high condensing temperatures.

Most refrigeration oils will start to break down or carbonize at temperatures of 350°F. The rate and degree of chemical reaction are undoubtedly related to the amount of oxygen and moisture in the system. Since the practical environment existing in an operating compressor of larger horsepower size is seldom contaminant free, field vulnerability may be much greater than in a carefully controlled laboratory experiment. The hottest temperature exists at the discharge valve port, and normally the discharge line within 6 inches of the compressor outlet will be from 50°F to 75°F cooler than the discharge port. Therefore 275°F discharge line temperatures represent an extreme temperature condition, 250°F is usually considered a danger level, and 225°F and below is desirable for reasonable life expectancy.

There are two schools of thought in the industry on oil sump temperatures. The more conservative view is that oil temperatures of 200°F or higher result in greatly decreased viscosity and marginal lubrication. On welded compressors, oil temperatures up to 240°F are considered acceptable on some models. Obviously the characteristics of the lubricant are critical, and bearings must be capable of withstanding the extreme temperatures. Lower temperatures are generally much more conducive to long life.

In the booming economy of the Mid-East in particular, where high ambient temperatures are a way of life, where technical expertise and service support are going to be stretched to the limit for years to come, reliability under adverse conditions may well become a far more important competitive factor than first cost. The cost of repetitive field failures could very well become prohibitive.

Obviously the suitability of a unit design becomes a matter of engineering judgment, and good judgment may be vital to a successful product.

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