Carlyle™

REDUCING NOISE LEVELS AND SOUND TRANSMISSION IN REFRIGERATION SYSTEMS USING HIGH SPEED, GEAR DRIVEN SCREW COMPRESSORS

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INTRODUCTION

This paper is intended to assist system design engineers in reducing the radiated noise level of high speed screw compressors applied in refrigeration systems.

BACKGROUND INFORMATION

During a comparison of sound levels between a refrigeration system containing high speed, gear driven screw compressors and one containing standard reciprocating compressors of identical horse power, the following holds true:

- Sound measured in decibels for both styles of compressor tend to be equivalent.
- Reciprocating compressors generate sound at a low frequency due to the low speed of the compressor components.
- Gear driven screw compressors generate sound at a high frequency due to the high speed of the compressor components.
- High frequency sound generated by a high speed screw compressor seems more irritating to the human ear than sound generated by other compression types. However high frequency sound is much easier to shield and/or isolate which reduces the potential for this sound to be irritating to anyone outside the machine room.

With the introduction of rotating screw compressor technology into the commercial refrigeration market, several new design challenges have come to light.

The first challenge was building a screw compressor in the size range useful for commercial refrigeration that has energy efficiency levels equal to or better than existing reciprocating compressor technology. This is the one critical requirement that had previously kept screw compressors out of commercial refrigeration.

This first challenge was met by paying close attention to the following two critical screw compressor design parameters.

- Internal clearances within the compression chamber.
- Rotating speed of the screw compressor rotors.

A screw compressor has no discharge or suction valves to seal off reverse flow of gas (or leakage) from high to low. Therefore it is critical that all internal components be machined and assembled for absolute minimum clearances. These precisely machined components and low assembly clearances are attained with the use of today's sophisticated computer aided manufacturing equipment.

Even with minimal clearances within the compressor, some leakage will occur. The next step necessary for achieving high efficiencies in a screw compressor is to decrease the effect of this leakage. The Carlyle twin screw compressors decrease the effects of this leakage by increasing the speed of the screw rotors with a geared drive system. Increased rotor speed increases the throughput

ratio of the compressor. (Throughput ratio is the ratio of refrigerant pumped to the volume of leakage.) Increasing this ratio of refrigerant pumped versus leakage will directly increase compressor efficiency.

Other benefits of high speed, gear driven screw compressors are:

- The physical compactness in relation to the compressor displacement.
- The ability to have different displacements within the same physical compressor body. This is accomplished by the use of different gear ratios which drive the screw rotors at different speeds.
- Less oil is required for rotor sealing. Less oil flow through the compressor means a lower oil cooling load and therefore a smaller less expensive oil cooler.

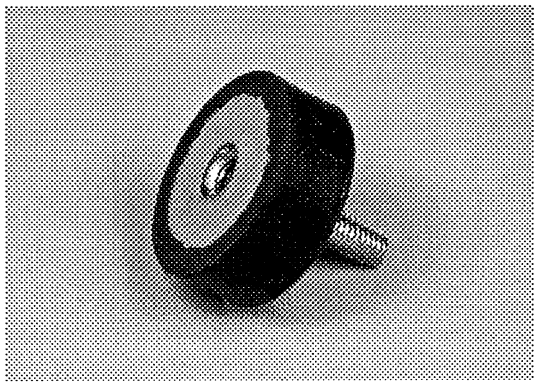
DESIGN RECOMMENDATIONS

By paying close attention to five basic design criteria, the potential for noise generation by high speed screw compressors can be efficiently and inexpensively reduced.

1. Compressor mounting feet.

To reduce the potential for compressor driven frame vibrations, isolation mounting feet should be used. As high frequencies are much easier to isolate, mounting feet used with high speed screw compressors may be much stiffer than the spring style mounts required for reciprocating compressors. As with any flexible compressor mount the attached piping must be designed to avoid excessive stress during start/stop transients.

The following picture is of a compressor mount which may be used with the Carlyle high speed screw compressor.



This is an isolation mount available from Karman Rubber Company or Carlyle Compressor Company.
Karman Part # K76, 50 - Durometer
Carlyle Part # KA75KR002
Rubber height = 3/4"
Diameter = 2"
Stud = 3/8"-16

Supplier is Karman Rubber Company.
Ph # (216) 864-2161
Fax # (216) 864-2124

2. Compressor mounting frame construction.

Any type of compressor, be it reciprocating or high speed screw, will vibrate to some extent. A reciprocating compressor will vibrate at a low frequency with high amplitude. A high speed screw compressor will vibrate at a high frequency with low amplitude.

Both compressor types require mounting frames constructed from heavy, strong materials.

Reciprocating compressors, due to the high amplitude vibration that they generate and the corresponding spring mounts required to isolate this vibration, are prone to discharge and suction line breakage. A solid mounting frame to support the compressor and piping can help to reduce the potential for these problems.

High speed screw compressors vibrate at a high frequency with very low amplitude and therefore may use much stiffer isolation mounts. Due to this low amplitude and stiffer compressor support, refrigerant and oil line breakage problems are virtually eliminated. Solid, heavy frame construction is necessary for high speed screw compressors to control the potential for noise generation by the frame. Heavier frame construction reduces the potential for frame movement and therefore reduces the potential for noise generation.

For these reasons it is preferable to construct compressor mounting frames for either style of compressor, using sufficiently heavy materials to prevent either compressor/piping movement or sound radiation.

3. Compressor discharge gas muffler

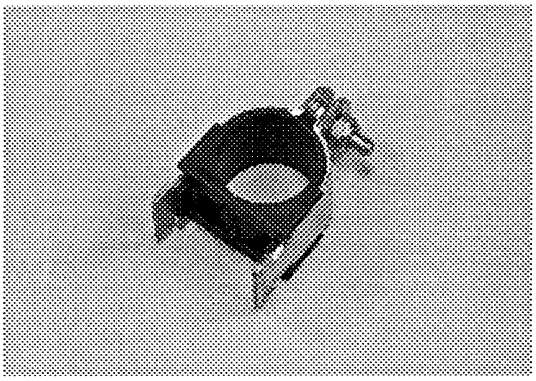
Discharge line mufflers are used on refrigeration systems to reduce gas pulsations caused by the compressor. With reciprocating compressors these pulsations may cause refrigerant lines to vibrate and break or radiate noise so the muffler therefore serves a dual purpose.

With a screw compressor the muffler is necessary only to reduce the potential for discharge line noise generation.

For a discharge gas muffler to be most effective it must be installed as close to the compressor discharge service valve as possible. If a discharge muffler is not used, compressor gas pulsations may travel through the discharge line and cause other system components to vibrate or radiate noise.

4. Compressor refrigerant line supports.

Due to direct coupling of the refrigerant lines to the compressor, vibration can be transmitted through these lines to any material to which the piping may be attached. Refrigerant lines should be clamped using vibration absorbing pipe clamps such as the one pictured below. Pipe clamps should be attached to framing supports which are rigidly supported for best performance.



This clamp has an insert made of soft rubber or plastic which is designed to dampen or eliminate transmission of

refrigerant line vibration to the supporting structure.

5. Machine room construction.

Construction of the machine room can play a very important role in controlling sound transmission to adjacent areas and sound level perception to the human ear.

Sound transmission to adjacent areas:

The good news is that, unlike reciprocating compressors, the high frequency noise and vibration generated by a high speed screw compressor can be easily contained within the machine room. This is not the case with reciprocating compressors which generate low frequency noise and vibration, that can easily travel through walls and floors to adjacent areas.

High frequency sound generated by the Carlyle screw compressor does not readily travel through walls or floors. This high frequency sound can only escape the compressor room via openings from one area to another. Therefore any openings such as pipe pass-throughs for refrigerant lines or electrical conduits should be completely sealed prior to operation of the refrigeration system.

Sound reducing ventilation ducts which limit sound transmission to the outside are readily available. Machine room designers should specify this type of ventilation duct when installing a machine room in any area where escaping noise can potentially affect the surrounding areas.

The use of a solid core gasketed door will reduce transmission of sound from the machine room. Specifying an outside door versus a non-gasket, hollow "inside" door will show a significant reduction in sound level transmission to an adjacent room.

Sound level control:

High machine room sound levels or at least the perception of high sound levels can be readily reduced with a little attention to room design. Machine rooms historically are constructed of either painted block walls or double walled sheet metal panels. Both of these style walls will readily "reflect" sound waves. The problem with sound waves being reflected is that there will appear to be more than one sound source thereby magnifying the effect of all sources of sound within the room to an unacceptable level. If the machine room walls were constructed of, or coated with a sound absorbing material this sound reflection would be eliminated.

Reducing the noise level in either style of compressor room will require that the hard reflective walls be in some way turned into softer more sound absorbent walls. When constructing a machine room with block walls Carlyle suggests that you consider any or all of the following.

- If possible do not paint the interior block walls. Most wall construction blocks have a somewhat porous finish which will help absorb sound waves. Once painted these blocks reflect sound rather than absorb it.

- Coat at least 50 percent of the interior walls (evenly distributed throughout the room) with a sound absorbing material or sound absorbing panels.

- Hang sound control panels from the compressor room ceiling to break up any sound reflection from the room ceiling.

- Consult a Noise Control Specialist for other ideas on room construction.

When constructing a sheet metal house type machine room Carlyle suggests that you consider any or all of the following.

- Construct at least 50 percent of the interior ceiling and wall panels (evenly spaced throughout the room) from perforated sheet metal rather than standard flat sheet metal.

- Use a sound absorbing material such as fiberglass insulation or duct board with the porous side facing the perforated metal to fill the walls.

- Consult your local acoustical materials company or noise control consultant for the proper sound absorbing materials. (Yellow Pages)

- Ensure that no solid wall panel is directly opposite another solid wall panel. This will help to limit the reflection of sound waves.

SUMMARY

Carlyle has offered a number of methods for reducing the noise level within the machine room. These methods include using isolation mounts on the compressor, a sturdy base, discharge mufflers, isolation pipe supports, and attention to machine room design. Most of these suggestions are simple, good engineering practices. Following all the above recommendations will reduce noise levels to less than the level found in a standard reciprocating machine room.

The noise level within a machine room using either reciprocating or screw compressors is similar when measured with a decibel meter. Carlyle's high speed screw design "sounds" louder to the human ear due to it operating at a high frequency when compared to a reciprocating compressor which operates at a low frequency. The advantage of the high frequency noise from the screw compressor is that the noise will be contained within the machine room, whereas the low frequency noise from reciprocating compressors. will travel through machine room walls and be "heard" in other parts of the building. Therefore screw compressors, which do not require additional sound control outside of the machine room, will actually provide a more pleasant working environment within the rest of the building.

Please contact Carlyle Compressor Company for more information on the benefits and advantages of applying Carlyle twin screw technology.