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Split Unit Evaluation

Overview

MSC was retained to investigate the piping configuration of a 100-ton Aaon rooftop mounted condensing unit and a Temtrol air handler mounted 6 floors below. It was reported that both Bitzer scrolls were condemned due to high head pressure and high FLA readings causing the unit to trip on the overloads. The piping installation was of concern and was to be inspected. The unit was down and inoperable with the space served with temporary units ducted into the system.

Scope of work performed

1. Identify and trace out the as-installed piping configuration, identify any traps.
2. Compare current installation to provided piping diagram.
3. Provide any recommendations to take corrective piping actions.
4. Provide any recommendations to any items observed.

Observations and technical notes

The condenser and air handler were non-operational at the time of inspection and the inspection and information that follows is based on a static operation. It is recommended that an inspection and troubleshooting can be done on the system when operational. The Aaon condensing unit (model #CAN-105-B-0-8-CA00A)is comprised of two nominal 50-ton circuits with one circuit being variable speed (Circuit #1) and the other being across the line (Circuit #2). The control of the condensing unit per the submittal was by others. The vertical rise of piping is contained within a chase with no access; the piping was only visible in the second floor mechanical room or the ceiling of the 7th floor and roof.

General notes

Refrigerant Piping:

1. The refrigerant piping does not contain any intentional traps. There are sections of piping that create "running traps" due to changes in elevations.
2. Due to multiple elevation changes in the horizontals in the mechanical room and the 7th floor ceiling, there is no uniform pitch of either the liquid line or the suction line. The suction line in the mechanical room is pitched from the ceiling level where it enters the chase, down to the coil level.
3. The liquid line as installed is 1-1/8" from the condensing unit to the air handler.

4. The suction line as installed is 2-1/8" from the condensing unit to the air handler.
5. There are numerous changes in direction in the piping which contribute to pressure drop. The use of 45's is prevalent instead of 90's in the system due to obstructions.
6. Piping doubles back and crosses over itself in a few locations throughout the pipe run. There is potential for cross connection where the crossovers occur.
7. There is no indication of the refrigerant charge amount inside the unit.
8. Other than TXVs, there are no refrigeration specialties on this system, i.e. LL solenoids, sight glasses, suction accumulators.

DX Coils:

1. Two interlaced, dual circuit coils vertically stacked with independent TXVs per circuit (four TXVs total).
2. TXVs are Sporlan OZE-25 valves and are in line with the distributors. The sensing bulbs are mounted at 11 and 1; it is recommended that they be mounted 45° from the bottom of the pipe (7 and 4).
3. The liquid line comes down to a common header with no liquid line solenoid or sight glasses.
4. There are no traps at the coil on suction line or the suction header. The coil suction stubs begin the common suction header between each circuit. The bottom coil exits as 1-5/8" then rises to connect with upper coil where they coin together and change to 2-1/8".
5. The coil circuiting starting downstream is Ckt #1 LL, Ckt #2 LL then Ckt #2 SL, Ckt #1 SL. Typically the leading liquid line is circuited with the leading suction line. The only labeling on the unit including the coils are handwritten numbering on the casing of the air handler.

Compressors:

1. Both compressors were condemned by others. Actual operation is unknown.
2. Circuit #1 compressor is the VFD compressor; it had ¾ of a sight glass of clear oil.
3. Circuit #2 compressor is the across-the-line compressor; it had ¼ of a sight glass of dark oil.
4. Control of the VFD is unknown. The submittal shows that the condenser is shipped without controls and provides a terminal strip for the compressor staging and control.
5. Presence of an "Oil Recovery or Oil Boost Mode" sequence is unknown.
6. Minimum speed at which the compressor is permitted to be operated is unknown.
7. It is unknown if any additional oil was added to the system to account for the field installed piping.

Air Handler:

1. The air handler serves the first floor medical spaces. It is unknown if the spaces are variable air volume or constant air volume. The control of the air handler should be identified to ensure proper airflow across the coils.

Conclusions

There is no one apparent issue that led to the compressor failures at the time of the investigation. A few primary concerns upon investigation that would contribute to compressor failure and poor system operation are refrigerant migration in the off cycle, compressor control, line set cross connection, refrigerant charge and oil management.

Liquid line solenoids are recommended to be installed and configured as solenoid drop so that when the compressor is off, liquid refrigerant does not migrate and log out in the evaporator coil. When refrigerant logs out in the evaporator, there is the potential for washout of the compressor oil to occur when the circuit is enabled and mixed quality gas is returned back to the compressor, potentially flushing the oil out of the compressor crankcase.

The sequence of operation for the variable speed compressor should be identified in order to verify if there is an "Oil Boost" or similar sequence for ensuring oil return. Should no such sequence exist, it is recommended that one be installed to address the potential of oil logging out in the system. The minimum turndown of the compressor should also be identified in order to verify adequate suction line velocity to promote oil entrainment.

The coil connections at the air handler are a concern as the numbering is atypical and there are no factory labels left on the coils. It is probable that they are piped correctly as the unit operated for a period of time. However, if they are in fact cross connected, it is possible that as long as both circuits are running simultaneously that the system operate. The system would likely trip on high head pressure or the overloads when only one circuit were to operate at a time as the system would be deadheaded. Further investigation should be performed or service reports ad readings verified to ensure that on circuit was operated at a time with satisfactory readings taken.

The refrigerant charge should be verified both for weight and air and non-condensables. Should the system be overcharged or charged with air and non-condensables, high pressure trips and high running load amperages are likely to occur.

One concern that was brought up is the lack of traps in the refrigeration piping, although common practice is to add suction line traps at every change of elevation as well as every 20' in a vertical rise. There is the possibility to have a fully functioning system with no traps as long as the velocity is such that the oil remains entrained. With that being said, traps are still recommended and should be pre-charged with oil. Typically the lower threshold for oil entrainment in the suction line occurs with velocities between 1000 and 1200 fpm. Verifying the compressor capacities and using the existing suction lie size of 2-1/8" at full load, the expected velocity is nearly 2500 fpm. With a 50% loading (25 tons) on the variable speed compressor, the resulting refrigerant velocity is nearly 1400 fpm. Reducing the compressor capacity to 20 tons brings the refrigerant velocity to 1100 fpm, which would be the lowest recommended turndown of the other compressor.

Other than a few running traps in the system and the worst one on the 7th floor ceiling, the general pitch of the piping from the time it enters the chase on the 7th floor is back to the coil connections. The piping is pitched from the ceiling level in the mechanical room down to the coil header at the air handler. Although not necessarily recommended, provided the refrigerant velocity is adequate, this should not pose a major issue. It is our (Mechanical Service Corporation's) position to include traps on any and all refrigeration piping in addition to designing the system for proper suction line velocity as it omits some of the factors of uncertainty.

Recommended Action Steps

1. Run/Confirm the compressors are suited and capable of running.
2. Recover the refrigerant and weigh out the charges on both circuits.
    a. Cut the piping for both circuits at the coil and cap all lines.
    b. Utilizing dry nitrogen, ring out the piping and coil piping ensuring the proper circuiting between the condensing unit and the coils as well as the proper connection of the equalization line and thermostatic elements for each TXV.
    c. Correct piping if necessary.
3. Install a liquid line solenoid valve and sight glass for each circuit just before the TXVs. Wire the solenoid valve for solenoid drop so they close when the compressor is turned off.
4. Install suction accumulators on each circuit at the condensing unit to ensure proper return of refrigerant and reduce the potential for liquid flood back to the compressor. This will also aid in metering the return of oil back to the compressor.
5. If feasible, install traps at the bottom of the riser. *Note the pipe velocity discussion.
6. Triple evacuate the system down to 500 microns and break each evacuation with system refrigerant to ensure a clean system free of any air and non-condensables.
7. Weigh in factory charge of the condensing unit with virgin refrigerant. Weigh in 50% of the calculated refrigerant charge for the piping.
8. Start-up unit and charge the unit with virgin refrigerant until the proper sub-cooling reading is achieved.
9. Verify the controls of the compressor both prior to operation via the sequence of operation and during the start-up of the compressors. Verify the staging sequence between both compressors. Verify if an oil return or oil management cycle is programmed and its operation.
10. Verify the controls of the air handler and the interlocking of the condensing unit.
    a. Verify what type of system the air handler serves and how is the unit being controlled.
    b. Verify the turndown on the airflow and the minimum airflow across the coil.
    c. Verify the condenser's compressor staging.
    d. Verify air handler and condenser interlock operation.

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TWO (2) IDENTICAL CIRCUITS

NOT FOR CONSTRUCTION