USA COIL & AIR NEWSLETTER

Sentry-Guard Freeze Resistant Coils

Water and steam have been used to cool and heat air in finned-tube heat exchanger coils almost since the inception of heating and air conditioning. Freezing of the fluid and the resultant coil damage have also been around for the same length of time. It is a systematic problem that many times is preventable, but we all know that this not a
perfect world. Nor are the HVAC and process systems that have been in service for decades.

It is fairly simple to understand the basics of a liquid phase freeze. The ambient conditions must be at or below 32 F, and that can, in turn, cause the water inside the coil to fall below 32 F as well. If kept below the freezing temperature of fluid long enough, the coil may be damaged by this condition.

Why coils fail

There are many different reasons for coil failures due to a freeze condition. In fact, there are too many to mention, but we have compiled a comprehensive list that certainly covers the majority:

- Controller (actuator) malfunctions and the outside air damper stays open. At the same time, fluid is not being pumped through the coil.
- Freezestat wrapped on the leaving side of the coil either is defective or does not cover the entire coil area. Thus, it does not shut down the system when a freeze condition is present.
- Coil is not drained properly for winterizing. Simply, water is laying in some or all parts of the coil tubes, bends, and/or headers, during peak winter months.
- Coil does not have adequate antifreeze solution added for winterizing.
- Valves, traps, or other water or steam accessories malfunction, trapping water or steam condensate inside the coil with low ambient conditions around the coil.
- Improper water coil design may trap liquid (not completely drainable).
- Steam distributing coils with long tube lengths or small-diameter inner and outer tubes may not be able to remove condensate quickly enough, trapping liquid in coil tubes and headers.
- Coil is so long that it should have a dual-feed design (supply connections at both ends) to provide an even flow of steam and condensate so that traps can remove the condensate. Most times this option is not selected because of physical restraints near the unit (walls or other equipment does not allow steam piping on the other side of the unit).

Pressure-the culprit

The key to understanding coil damage due to a liquid phase freeze is the extreme pressure produced during the formation of ice. The area that contains this ice can only handle this added pressure until it reaches a limit that causes heat exchanger damage and subsequent failure. The pressure limit is a variable limit based on many different factors, including coil construction, especially involving the tubes and return bends and also systematic life deterioration, The original coil construction deteriorates the longer it is in service. Walls of the tubing, and especially return bends, thin out because of water or steam velocity. There also may be corrosive agents involved that can cause stress corrosion cracking, crevice corrosion, or general corrosion fatigue, thus reducing the maximum freeze pressure of the coil.

Most new initial coils are constructed to withstand well over 1000 psi easily. Bursting pressures of bends and tubes are such that they can individually handle well over 1800psi. It then must be very obvious that the pressure inside a heat exchanger coil during a freeze cycle is very high.

Where does a coil fail? The answer is fairly simple and consists of two main factors: the circuitry of the coil where the pressure builds and the weakest point in that circuit. Extensive testing has shown that the failure will appear as a bloated area in the tube header or bend that has expanded. Then, in most cases the area will rupture. This area at the weak point almost always looks like “12 pounds in a 10 pound bag.” It is clear that the point has experienced great stress and has tried to contain pressure by deforming (expanding) and then finally upturing. Natural pressure relief is simply destined to be at the weak point in the circuit.

Pressure relief-the answer

Finned-tube heat exchanger coils have operating and test pressures well below the 1000psi minimum required to damage a coil during a freeze. Tables 1 and 2 show maximum operating and test pressures for often-used materials in HVAC and process heat exchanger coils.

Take note that coils constructed with copper tubing and headers (the most widely used construction for HVAC coils) have a pressure rating of 250 psig from -30 to 250 F and a test pressure of 400 psig for water coils. Steam coils are 100 and 400psig, respectively. The object is to provide a pressure relief device that will automatically fail above the test pressure (since it is the highest coil pressure for any given construction) and yet still below the pressure of a liquid phase freeze.

To summarize, adverse pressure is the cause of freeze damage to a coil, and the relief of that pressure is the solution. A new coil has entered the marketplace to address this issue. It features a patented pressure relief design, is economically feasible, and does not affect the other performance characteristics of any coil. Along with the capability of replacing or fabricating almost any coil, regardless of its age, make, or construction, this new coil can relieve the owner of a major problem that has existed since the inception of heat transfer. Please go to the coil section under products and “click on” Sentry-guard. You will find everything you need to understand special Sentry-guard freeze resistant coils.

TABLE 2 - Pressure/temperature (psig) table for circuiting fluid coils.

Tube material	Header material	Temperature, F (-30 to...)										Use on models	Test pressure psig
		250	300	350	400	500	600	800	1000	1200	1600		
0.028 copper	Type K copper	250	200	120									
	0.083 min. wall steel	250	250	250	230								
0.049 copper	Type K copper	250	200	120								HW CW	400
	0.083 min. wall steel												
0.049 admirally brass	90/10 cupro nickel												
0.035 90/10 cupro nickel	90/10 cupro nickel	250	250	250	230								
0.049 90/10 cupro nickel	90/10 cupro nickel												
0.049 70/30 cupro nickel	70/30 cupro nickel												
0.049 aluminum (1100)	Sch.40 aluminum pipe	250	200	150									
0.049 90/10 cupro nickel	90/10 cupro nickel	250	250	250	250	150	50						
0.049 steel	0.083 min. wall steel	250	250	250	250	250	250	150					
0.065 steel	Sch. 40 steel pipe	400	400	400	400	400	300	200				HW CW	600
0.035 304 LSS	0.083 min. wall 304 LSS	250	250	250	250	250	250	250	250	200	100		400
0.049 304 LSS	Sch. 40 304 LSS	400	400	400	400	400	400	400	300	200	100		600
0.035 316 LSS	0.083 min. wall 316 LSS	250	250	250	250	250	250	250	250	200	100		400
0.028 copper	Formed steel												
0.049 copper	Formed steel												
0.035 90/10 cupro nickel	Formed steel	100	100	100								HW CW	150
0.035 304 LSS	Formed 304 LSS												

TABLE 1 – Pressure limit table for steam heating coils.				
Tube diameter, in.	Tube material	Header material	Maximum recommended steam pressure, psig	Test pressure, psig
0.625	0.025 copper	Type K copper	100	400
	0.049 copper	Type K copper 0.083 min. wall steel	100 150	400 400
0.875	0.032 copper	Type K copper	120	400
	0.045 copper	Type K copper 0.083 min. wall steel	120 230	400 400
0.625	0.035 90/10 cupro nickel	90/10 cupro nickel 3/16-in. formed 304 SS	230 230	400 400
	0.049 90/10 cupro nickel	90/10 cupro nickel 3/16-in. formed 304 SS	230 230	400 400
0.875	0.035 90/10 cupro nickel	90/10 cupro nickel 3/16-in. formed 304 SS	230 230	400 400
	0.049 90/10 cupro nickel	90/10 cupro nickel 3/16-in. formed 304 SS	230 230	400 400
0.625	0.049 aluminum	Sch. 40 aluminum pipe	120	400
0.875	0.058 aluminum	Sch. 40 aluminum pipe	120	400
0.625	0.049 steel	0.083 min. wall steel	250	400
	0.065 steel	Sch. 40 steel pipe	400	600
0.875	0.049 steel	0.083 min. wall steel	250	400
	0.083 steel	Sch. 40 steel pipe	400	600
0.625	0.035 304 LSS	0.083 min. wall 304 LSS	250	400
	0.049 304 LSS	0.083 min. wall 304 LSS Sch. 40 304 LSS pipe	250 400	400 600
0.875	0.035 304 LSS	0.083 min. wall 304 LSS	250	400
	0.049 304 LSS	0.083 min. wall 304 LSS Sch. 40 304 LSS pipe	250 400	400 600
0.625	0.035 316 LSS	0.083 min. wall 316 LSS	250	400