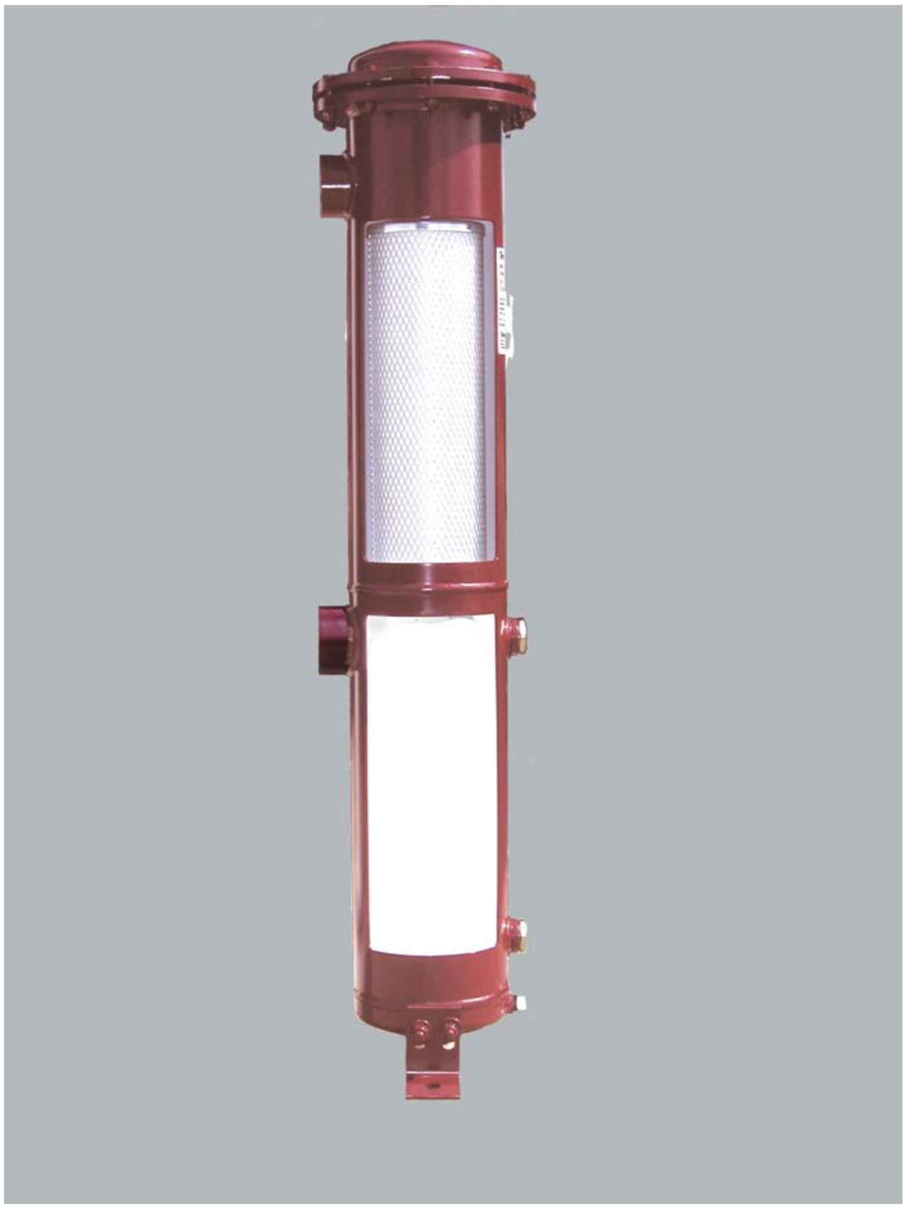
Coalescing Oil Separators:

Technology that improves performance and reduces energy costs of commercial refrigeration systems.



Russell Cooper
Emerson Climate Technologies

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Introduction

For good reason, supermarkets and other food retail operations today are going to great length to save every last dollar of the cost of energy consumption. Solutions and payback are becoming more complex in an era of systems monitoring, efficiency consultants, increasing use of controls and automation, and performance contracts.

Beyond these efforts though, it is refreshing to discover that significant cost savings can still be gained because of enhancements at the basic component level. New ideas – compressors that modulate, coaxial heat exchangers that improve efficiency through throttling, stepper motors with more precise control of flow, high efficiency fan motors – are everywhere. You just have to know what to look for and what to specify.

Coalescing oil separators fit neatly into this camp. By specifying their inclusion on your commercial refrigeration system, you may reduce energy consumption from the very moment of system start-up. These separators typically cost 15% to 25% more than competing, centrifugal models. However, the energy cost savings may dictate an almost immediate payback.

Purpose of Oil Separators

Components such as filters, dryers, and oil separators protect your refrigeration system from contaminants, prevent moisture and acid build-up, and regulate proper oil circulation. While there exists more than one type of oil separator technology, they all serve the same general purpose of prohibiting excessive oil circulation. Oil is isolated early on the discharge line and returned to the compressor.

The sole purpose of the oil is to lubricate the compressor. When oil circulates instead, it builds up a thin film on the internal surfaces of heat exchangers, and acts as an insulator. This robs the system of efficiency and raises energy consumption.

In addition, refrigeration systems have a fixed volume, and if the mass flow of refrigerant (capable of heat removal) is competing for that volume with an excessive mass flow of circulating oil (not capable), cooling capacity is reduced for a given energy input, again raising costs.

How Coalescing Separators Work

Coalescing separators are capable, with proper design, of removing 95% to 99% of the oil component of mass flow. They use a filter media of highly pure glass fibers, capable of exciting even the smallest oil molecules. This material forces the molecules to collide and form larger droplets, which in turn are routed by gravity through a drain layer.

It is interesting that coalescing type separators maintain the same level of effectiveness regardless of system velocities and loads. This is increasingly important as more stores employ refrigeration load shifting/matching to reduce energy consumption. Rival centrifugal designs do not share this ability, and their efficiency drops as load does.

To be certain, many points of debate have existed over the abilities and performance levels of rival separator designs. The point of this examination is not to enter into that debate, or offer speculation on a wide range of benefits.

Rather, the purpose is simply to examine and educate around one area of quantifiable benefit – and that is the ability of coalescing separators to increase system capacity, reduce energy costs for a given load, and justify their specification, even at a first cost premium, through a rapid and certain return on investment.

It is somewhat ironic that the current area of broadest application for coalescing separators happens to be that of biological storage. These are environments of high value, high reliability climate control, where the cost of energy consumption is at best an afterthought, and usually never even a design consideration.

Independent Lab Results Point Towards Savings

Test Background

In order to better explain the potential energy savings of coalescing separators, a test was commissioned to conservatively evaluate whether practical results, seen for years, could be documented under controlled laboratory conditions. Specifically, we sought to evaluate whether a typically configured refrigeration system, equipped with a coalescing type oil separator, consumed less energy per ton of cooling than a system with other types of separators, or no separator at all.

By conservative, I refer to the fact that tests were done without cycling/unloading procedures. Instead, higher circulation velocities were employed to insure that all separators were tested near rated load, and operated at peak design performance. This eliminates any possible penalty for separators with velocity dependent efficiencies. Furthermore, while greater savings could have been available at low temperature operating conditions, tests were conducted under medium temperature conditions to insure a more level playing field. Today, the medium temperature suction group usually accounts for 65% to 85% of the total cooling load of a store.

The test system utilized a 7.5 HP Discus compressor, and a calorimeter to simulate the evaporator side (display case). The tests were run at ARI medium temperature test conditions used to rate compressors, and employed R404A for refrigerant and POE oil for the lubricant.

A baseline test was performed on the system without any separator. The test was then repeated with four, unidentified separators. Although unknown at the lab, Sample A was a centrifugal design from manufacturer #1. Samples B and C were impingement designs from manufacturer #2. Finally, Sample D was a coalescing design from manufacturer #2.

The lab reported on pressure drops, percent of oil circulation, system capacity, Energy Efficiency Ratio (EER), and the energy use per ton of refrigeration capacity (kW/ton). Data for each sample system were collected on the same timeline in the test sequence, that being when the system reached stabilization.

Findings

Back to the fundamentals explained earlier, the key to reducing energy costs is to keep the oil from circulating in the system, where it coats heat exchangers, and reduces the level of refrigerant mass flow.

Table 1

Model	Oil Pressure	Separator △ P	% Oil Circulated
Baseline	40.5 PSI	2.0 PSI	0.302
Model A	38.5 PSI	7.8 PSI	0.065
Model B	32.5 PSI	6.9 PSI	0.067
Model C	33.5 PSI	6.0 PSI	0.040
Coalescing	33.0 PSI	7.0 PSI	0.003

Referencing table #1, it should come as no surprise that all sample separators had a substantial effect over the baseline system. But while competing separator types were able to reduce the percent of oil circulating by upwards of 87%, the coalescing design went further, reducing the amount by over 99% from the no-separator baseline environment. The rationale for improved energy efficiency is therefore present.

Now turn to table #2 below. As theory would suggest, with less oil impairing refrigerant mass flow and heat exchange, the coalescing configuration had the highest measured capacity of refrigeration (BTU/Hr). While the performance difference is less clear on the energy input (Watts) part of the equation, the bottom line of the analysis is found in the determination of how much energy (kW) is required per unit of cooling (ton).

Table 2

Model	Capacity Btuh	EER	Watts	Amps	kW/ton
Baseline	50560	7.68	6587	20.70	1.563
Model A	50509	7.69	6572	20.69	1.561
Model B	50589	7.72	6553	20.68	1.554
Model C	50625	7.69	6583	20.80	1.560
Coalescing	50650	7.74	6544	20.78	1.550

The differences in these numbers may appear small to someone not familiar with the application environment. While the controlled experimental environment helps to raise confidence in the accuracy of these numbers, a reasonable person might ask how a one-one hundredth improvement – from 1.56 kW/ton to 1.55 kW per ton – could possibly translate into savings that are important enough to make a difference.

Well it is very possible, and to understand why it is necessary to take these measured results and think about them applied in a supermarket, an environment of relatively large refrigeration loads and energy costs.

Energy Savings From Improved Performance

Supermarket Settings

While it is not possible in the space of this paper to prescribe potential savings for applying coalescing separators in every possible supermarket setting, simplistic modeling of energy savings in two different case studies may prove helpful.

When choosing a supermarket, cleanliness, high quality produce and meats, friendly employees, and convenient location tend to be the major criteria cited by consumers. To address these requirements, store operators are orienting designs in two directions.

One approach is new, smaller neighborhood or city markets, a cross between scaled down supermarkets and scaled up c-stores, offering value through proximity, human scale, and greater variety of fresh and prepared foods. An alternative approach is the superstore, offering one stop convenience for a full range of periodic shopping needs in a single large format store.

Projection of Savings and Payback

You can imagine how the refrigeration requirements of such formats could differ greatly. But the opportunity to employ coalescing separators to reduce energy costs is available in both cases, with validity equal to the results seen in controlled lab results. Scaling up the improvement factor with very large refrigeration loads creates the opportunity for significant savings.

For instance, let's just look at how the differential effect can turn into sizable savings when you apply it in a store analysis in Tables 3-5. In these tables, let's examine a model store with 167 tons of cooling requirement. This fits somewhere in the middle of the road as far as store size goes. The other assumption is that 40% of the capacity is low temperature, and the remainder is medium temperature. Finally, assume that the cost of electricity is $0.085 per KW, a figure somewhere near the average of what one finds in the United States. Using the tables as a worksheet, you can bring this analysis alive by placing the real parameters for your chain right alongside those of the model chain.

Table 3 - Annual Store Energy Savings

	The Formula	Tons	x	Differential	x	Run Hrs.	x	kW Cost	x	Days/Yr.	=	Savings
Med. Temp. Capacity	- Model Store	100	x	0.011	x	24	x	$0.085	x	365	=	$ 819
	- Your Store		x	0.011	x	24	x		x	365	=	
Low. Temp. Capacity	The Formula	Tons	x	Differential[1]	x	Run Hrs.	x	kW Cost	x	Days/Yr.	=	Savings
	- Model Store	67	x	0.0187	x	24	x	$0.085	x	365	=	$ 933
	- Your Store		x	0.0187	x	24	x		x	365	=	

[1] In our model, the 0.011 medium temperature performance differential is adjusted by a 1.7 multiplier (0.011 x 1.7 = 0.187) to approximate the greater effect at low temperature conditions. *Actual* medium temperature lab conditions witnessed energy consumption of 1.319 kW/ton. *Model* low temperature consumption is estimated to be 2.246 kW/ton.

Table 4 - Chain Energy Savings

Total Chain Energy Savings	Medium Temp.	+	Low Temp.	=	Store Savings	x	# of Stores	=	Annual Savings	Saving Over 10 Year Life
Model Savings	$ 819	+	$ 933	=	$ 1,752	x	50	=	$ 87,600	$ 876,000
Your Savings		+		=		x		=		

Table 5 - First Cost Investment

Total Chain Investment	Med. Temp. # of Separators	x	Cost Adder	+	Low Temp. # of Separators	x	Cost Adder	x	# 0f Stores	=	Incremental Investment
Model Chain	2	x	125	+	2	x	125	x	50	=	$ 25,000
Your Chain		x		+		x		x		=	

Observe in Table 3 that, on an annualized basis, with continuous operation, using the coalescing separators instead of the conventional type could save upwards of $1752 per store. And the additional, up-front cost (See Table 5) to specify this approach could be as little as $500. That's an attractive return on investment to almost any business.

The purpose of Table 4 is simply to put these types of savings into the context of installation across a chain of stores. Furthermore, with a life expectancy of roughly 10 years, the energy savings are compounded year in and year out, while the investment remains fixed at the first cost, installation premium for the technology.

You can arrive at your own estimate of expected savings by knowing just a few critical items that define your store's operating environment. How many BTUs of cooling capacity are required by the store, and how is that capacity divided between low and medium temperature requirements? How many compressors, and thus oil separators, are required by the system? What is the system's percent of run time? And finally, what is the cost of energy at the location?

Take time to gather this information, and complete some simple calculations. You may discover that you have more incentive than you realized to instruct your OEM or service contractor to install coalescing oil separators on your refrigeration system, even with a slight added up front investment.

Additional Benefits

To reiterate, the focus of this paper's recommendation is on energy savings, and the support of such a position based on the findings of a controlled experiment that evaluated different oil separator designs. Employing a coalescing separator could offer additional benefits that I will however mention strictly for the purposes of a thorough discussion.

Reduction of required system oil volume – If less oil circulates, then less is required to be injected into the system at start-up to meet the requirement of simply lubricating the compressors.

Reduction of start-up time – Being more effective in limiting oil circulation, coalescing separators may require smaller levels of initial oil charge to the reservoir. This would translate directly into savings on the cost of oil and start-up labor. Because there have been, and continue to be, different separator technologies, you may want to investigate compressor and system specifications closely. Are the specifications helping you to take advantage of a reduced oil requirement, or are they written to cover a range of separators, even those that allow higher circulation rates?

Sound level reduction – While tunable mufflers are still recommended in systems with unusual pulsations, when this is not an issue, oil separators, which reduce velocities internally, can act as simple discharge line mufflers.

Reduction of oil slugging – When excess oil gets trapped in evaporators, and refrigerant velocities increase to compensate, there is a threat that the oil may suddenly return all at once to the compressor in the form of an liquid slug. This can cause severe damage to a compressor, which is a costly component to replace.

Elimination of solid contaminants in system – The internal properties of coalescing separators make them excellent system filters as well. The average coalescing separator possesses much more filter area than standard filter/dryers or suction line filters, and is capable of trapping particles of 0.3 microns and larger. Contaminants are threats to any mechanical component in the system, especially metering devices.

Reduction of Compressor Cycling – If oil circulation is reduced, then the mass flow has a larger refrigerant component and more cooling capacity. This will act to effectively reduce the total demand for run cycles on the compressor over time. The longevity of a compressor is closely tied to the number of cycles (on/off) it experiences in service.

Elimination of redundant components – Presented with the elimination of oil carryover, smart system design would suggest the removal, or downsizing, of oil reservoirs, which may not be as necessary. And fully exploiting the filtering capabilities of the coalescing separators may make it possible to eliminate suction line filters.

Intelligent systems and products will play an ever-increasing role in helping stores to simultaneously increase revenue and minimize costs. And that is not always an easy balancing act. A store without lights may save lots of energy, but sell little food. It's more important than ever to take advantage of the opportunity for savings that exist strictly behind the scenes – as with coalescing oil separators.

As I pointed out in the beginning of this paper, the world is changing and the infrastructure – from hardware to consultants – required to plan, monitor, and track energy savings is everywhere. You owe it to the financial health of your chain to demand that your refrigeration system manufacturer, performance contractor, or energy consultant find and deploy high return-on-investment technologies.

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