FCI FoodChain INTELLIGENCE

Chain of Thought

Knowledge...Innovation...Action

Vol.2 No.2 July 2009

Welcome to our July newsletter

It is with pleasure that I open this 'Chain of Thought' edition with the news about the re-scheduling of the 1st IIR conference on the cold chain, now to be held in Cambridge, UK. The theme is "Sustainability and the Cold Chain" and will run over the 29-31st March 2010. The deadline to submit an abstract is 15 September 2009.

As part of the International Scientific Committee, I encourage you to visit the website (www.icccuk2010.com) and consider attending this conference.

With this event in mind, I have selected two topics for this newsletter: (a) food security in pandemic scenarios; and (b) the effect of air-side fouling on the performance of evaporators in refrigeration systems.

Please send your feedback to info@food-chain.com.au. As always, feel free to forward this newsletter to colleagues that may find it of interest.

Happy reading,

Silvia Estrada-Flores

In this issue...

Food Security in Pandemic Scenarios. Part II.

First of all, you may be wondering where is Part I and if you missed one of the 'Chain of Thought' newsletters.

I wrote Part I in my blog, 'Chain of Events". The note can be found here. When I started writing this note, I realized that I had more to say than I initially thought (this is a common occurrence, as those who know me are aware of). So I decided to extend it to an article and here it is.

First of all, what is exactly food security?

I found the following definitions:

(1) "Access by all people at all times to enough food for an active, healthy life." (World Bank).

(2) "All people at all times have both physical and economic access to the basic food they need." (FAO Committee on World Food Security).

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(3) "Access by all people at all times to sufficient food and nutrition for a healthy and productive life" (The Agricultural Trade Development and Assistance Act,1990).

(4) "When all people at all times have access to sufficient food to meet their dietary needs for a productive and healthy life" (USAID Bureau for Africa, 1986).

(5) “When all people at all times have both physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life”. (USAID, 1992).

Or we could define the antithesis (food insecurity): “Irregular access to safe, nutritionally adequate, culturally acceptable food from non-emergency sources” (VicHealth, 2009).

The word “access” highlights the concept of looking at food chains as a whole rather than food production separate from distribution and consumption.

Kate Carnell, CEO of the Australian Food and Grocery Council, made a point about catastrophic events during her speech to the National Press Club in April this year. She put it bluntly: if all Australian domestic food supply chains came to a halt tomorrow, how long our food supply would last for? Her answer was 8 to 10 days.

After I requested information to a few individuals about how prepared is the Australian industry to respond to pandemic scenarios, an AFGC statement (again from Kate Carnell) in May 2009 made it clear that the Australian industry has a plan.

The Pantry List

The industry’s planning team (RAWG or Retail Industry Working Group) has representations of major suppliers, retailers (*i.e.* Metcash Ltd/IGA, Woolworths Ltd and the Coles Group) and government. The team has been working for three years now to plan for crises that might affect the supply of essential food and grocery items.

While details of these plans are not available for obvious security reasons, RAWG has a food distribution plan to coordinate all the players in the food supply chain in case of food shortages, to ensure a “fair and orderly distribution” of essential items across Australia.

Steven Newton is the National Technical Services Manager for Metcash and he chairs the RAWG team. In 2008 and before the swine flu scare, he gave an enlightening presentation at the Impetus 2008 conference. Factors that were taken into account to develop the food distribution pandemic plans were:

- Australia’s food supply chain is driven by just-in-time management and consumers are used to just-in-time shopping, 24/7.
- Before the plan, there was about a month’s worth of shelf-steady items in the supply chain. Even this was reducing, with no stockpiling capacity and minimal surge capacity.
- In the fresh food supply chain there was a maximum of five days supply, estimated to run out within two days in metropolitan areas.
- About 40% of the meals are not consumed at home.
- 95% of homes have 2-4 days worth of pantry stock.

As a response to these factors, the RAWG developed an emergency pantry list, which can be accessed at: http://www.pantrylist.com.au/.

The list provides guidelines to increase household resilience by ensuring 14 days pantry stock level. This list does act as a reminder (much as a supermarket shopping list) to ensure we are not forgetting the essentials.

This is a good start. Is it perfectible? Yes. I would like to see:

- Recommendations on minimum water intake per day for a healthy person and minimum nutrition intake per day, according to age, weight and height.
- Recommendations for dietary supplements that may help to balance a deficient diet (e.g. the use of vitamins and fibre when availability of fresh fruit is limited).
- Recommendations on rations per day (including lactose intolerant diets, vegetarians and halal).
- A calculator that helps shoppers to estimate their minimum requirements for 14 days.
- Beyond avoiding door openings, recommendations for maintaining low temperatures in refrigerators during out-of-power situations. For example, the use of plastic bottles filled with water or gel packs placed in unused spaces within the chiller or freezer, to slow down food temperature increases.

- And definitely, more information on food safety and hygiene. For example, the use of contaminated water is a classic factor that contributes to the spread of cholera in emergency situations. Education on emergency drinking water options could be valuable.

Are we safe yet?

With plans to respond to emergency scenarios in the Australian food supply chains, I feel reassured that the capacity for a rapid response to catastrophic events exists.

But there are pervasive issues that will not bring to a screeching halt our food chains.

Current disruptive events such as the turmoil of global financial markets, the symbiotic relationship between food production and environment and increasing production costs can lead to a profound transformation of food production systems.

From these, Prof. Julian Cribb maintains that securing water for food production is the most pressing problem for agricultural enterprises worldwide. Prof. Cribb has said that the volume of fresh water available to grow food is now in decline and that farm outputs will have to double in the next years, while using only two thirds of today's water volume.

Therefore, a fundamental question is, how can the global agri-food sector can produce more with less?

My view is that the answer to this question will require a holistic vision of food chains, whereby competitiveness is conceptualized as a function of the cumulative efficiency of the supply chain partners. The key role of innovation on lifting the competitiveness of the industry needs to be recognized and addressed in the strategic plans of industry and Governments worldwide.

Despite the lack of an organised approach by most Governments worldwide, innovation in food chains is already occurring. In some cases the innovators are the consumers themselves. Emerging innovations include:

(1) The rise of urban, local and regional chains: issues such as food security, power imbalances in food chains, environmental impact of food transport, obesity and other health issues attributed to the strategies of multinational food companies have led to some disillusion among consumers on current food systems and the growth of companies that embrace ethical sourcing and environmental awareness. Interest in local and regional distribution models that connect growers with consumers has ramped up globally since 2007 with examples such as the FoodConnect enterprise in Australia, the eFarm company in India and the "Von hier" brand from the German retailer Feneberg.

(2) The sharing of distribution networks and infrastructure. Companies are now re-evaluating the way they store and move goods in the context of supporting continued economic growth, while protecting the environment. Some current examples demonstrate that enterprises are now willing to cooperate with other firms (even with competitors) to improve economies of scale and decrease logistics carbon footprints. Examples include:

- The ECR Sustainable Distribution Group initiative (UK)), which aims to save food and grocery industry mileage by sharing vehicles and improving the efficiency of warehousing networks.
- The SmartWaySM Transport (USA), an innovative collaboration between the Environmental Protection Agency and the freight sector designed to improve energy efficiency, reduce greenhouse gas and air pollutant emissions, and improve energy security (EPA, 2009).
- The Clean Cargo Working Group (USA), which is a multi-sector, business-to-business collaboration between ocean carriers, freight forwarders and shippers of cargo. Members of this group include Coca-Cola, Wal-Mart, Chiquita Brands and Starbuck's, among others. Tools used to enhance communication between participants are annual environmental surveys, intermodal emission calculators and CSR performance surveys (BSR, 2009).

(3) The growth of supermarket-led initiatives to optimize supply chains. Examples include:

- Woolworth's Limited Environmental Sustainability plan (Australia), which aims to achieve a 25% reduction in CO_2-e per carton delivered by 2012 through the reduction of distance travelled, the introduction of new vehicle designs, the use of alternative fuels and the use of hybrid trucks (Woolworth's, 2008).
- The Woolworths Holdings Limited initiative (South Africa) to reduce relative transport emissions by 20%, through restricting air-

freight of food products and sourcing food regionally wherever possible reducing reliance on long distance road transport.

- The Wal-Mart's Sustainability 360 initiative (USA-global), which aims to reduce the number of trucks by re-designing the supply chain network, changing the presentation and size of food products and using auxiliary power units in their truck fleet .
- The redesign of the Tesco distribution network (UK), which aims to reduce 50% emissions per case by 2012. Tesco's supply chain infrastructure includes 29 warehouses and over 2,000 vehicles travelling 659 million km across the primary and secondary transport operations. Tesco is measuring the carbon footprint of three of its major food categories (tomatoes, potatoes and orange juice). Tesco has also committed to reduce packaging by 25% over the next 3 years.

Other strategies that can also contribute to the sustainability of food distribution systems are:

- The use of real-time telematics and computer routing and scheduling (Robson et al., 2007).
- The implementation of alternative transport modes (e.g. rail and water ways).
- The use of hybrid trucks, which increase fuel efficiency 30-50 % .
- The use of alternative energy sources for powering cold chain infrastructure. For example, the combination of grid electricity and power derived from wind (eolic) energy .
- Packaging optimization and removal of excess packaging (Robson et al., 2007).
- The use of hydrogen cells to power forklifts in distribution centres.
- The use of supply chain network modeling as an aid to reducing food shipping carbon footprints (Robson et al., 2007).

Novel developments on these areas are likely to continue in the next decade. This author believes that innovation can successfully become the driver to transform food supply chains. Innovation will enable the world to supply safe, wholesome and affordable food in an environmentally-challenged future.

References (not linked to a website):

Robson, S., Fisher, D., Palmer, A. and McKinnon, A. 2007. Reducing the External Costs of the Domestic Transportation of Food by the Food Industry. Report for the Department for Environment, Food and Rural Affairs. Faber Maunsell. 73 pp.

Dirty Evaporators: Air-Side Fouling and its Effect on Evaporator Performance

A dirty evaporator in a cold store, refrigerated transport or air-conditioning unit means that the evaporator's external surface is covered with dust, dirt, or biofilms (e.g. moulds).

A variety of technologies have been tested to clean coils in air conditioning and refrigerated systems, such as ultraviolet lamps, pressure washing, chemicals and biocides, all with advantages and disadvantages. In-depth studies exist on the use of biocides in HVAC systems, but their use in refrigerated storage has been less investigated. The two major concerns in terms of deposition of biological materials on coils are fungi and bacteria. Fungi are often allergenic or toxic themselves, although we are often more concerned with their spores that can also be allergenic and toxic. Additionally, as fungi grow, they can produce mycotoxins, metabolic by-products that can be harmful to humans.

Bacteria can also be allergens and cause disease and sickness. Some common bacteria that causes concern in the food industry are *Listeria spp., coliforms and enterococci.*

Effect of microbial contamination on the evaporator coil

Evans *et al.*(2006) surveyed 15 food processing plants handling a variety of products such as salads, ready-to-eat meals, raw poultry and others chilled products. Microbial swab samples were taken at day 1 and after 6 days of the initial visit in seventy two cold rooms. The results showed that twelve out of the fifteen plants had at least one chilled room where microbe counts were above 5 $\log_{10}$ cfu cm^{-2}.

The bacteria present was *Listeria spp., coliforms, enterococci, S.aureus* and *B. cereus*. The level of contamination varied significantly between factories and no correlation between temperature, relative humidity, airflow and the number and types of bacteria was detected. Further trials with an experimental evaporator indicated that bacteria could be transferred from the surface of the evaporator to the air within a cold room. Little bacteria growth was found on clean evaporators.

Effect of fouling on the energy use of refrigeration systems

Coil fouling is defined as an increase in pressure above 100% and a decrease of heat transfer below 100% when compared to a new coil's performance. Reduced air flows from coil fouling can cause typical degradations of less than 5%, but can be much greater for marginal or extreme conditions, where the units are operating on a steep part of the fan curve or have low refrigerant charge.

To understand the effect of external fouling on coils, we need to review some heat transfer concepts.

The temperature differentials for evaporators are proportional to the heat transfer coefficient of heat transfer surfaces, the area of the coil and the rate of heat flow being transferred from the refrigerant to the air. The relationship between these factors in an evaporator is shown in Eq. (1):

$$Q_{evaporator} = U\ A\ \Delta T_m \ldots\ldots\ldots\ldots\ldots(1)$$

Where

$Q_{evaporator}$= heat flow between the evaporator coil and the cold store (W);

U = overall heat transfer coefficient (W m^{-2} K^{-1});

A= area available for heat transfer (m^2);

ΔT_m= logarithmic mean temperature difference between the air and refrigerant. Figure 1 illiustrates this concept further.

Fouling in the coil affects two parameters of Eq. (1): the heat transfer coefficient U, which is a measure of the resistance to heat transfer between air and refrigerant flowing inside the coil, and the heat transfer area A.

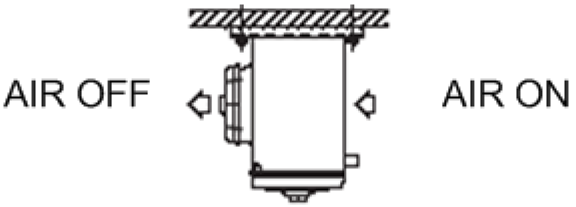
The expected effect on heat transfer is very small, for two reasons:

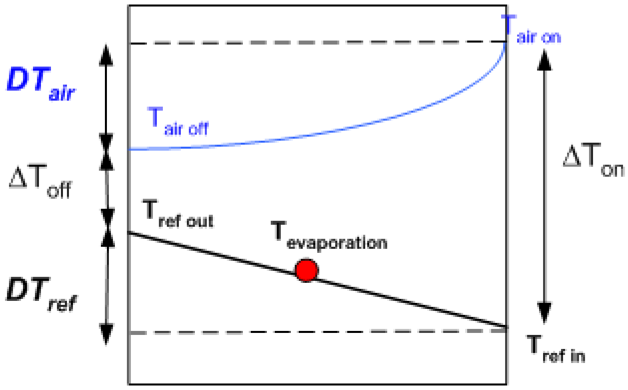
(a) Effect on U: the foreign material will normally deposit within the fin's discontinuities (face fouling). The insulative effect of the film is therefore located at the end of the fin, which has little impact on the fin's efficiency, as very thin fins are typical of HVAC systems.

(b) Effect on A: the area covered by deposited particles is very small, compared to the total heat transfer surface available in the evaporator (i.e. fins and pipe area).

How does fouling affect the evaporator's fan performance?

Air velocity through the evaporator coil affects both fan energy and heat transfer performance (Figure 2).





$$\Delta T_m = \frac{\Delta T_{on} - \Delta T_{off}}{\ln\left[\frac{\Delta T_{on}}{\Delta T_{off}}\right]}$$

Figure 1. Typical temperature differences used to assess temperature performance in evaporators. ΔT_{on} is the temperature difference between the air-on and the evaporation temperature (calculated as the average of the refrigerant temperatures at the inlet and outlet). ΔT_{off} is the temperature difference between the air-off and the evaporation temperature.

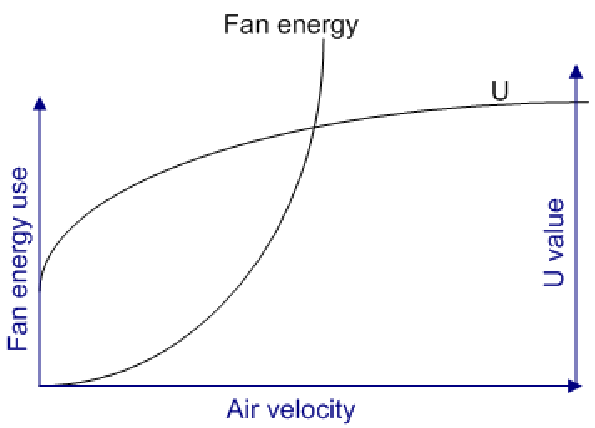


Figure 2. Relationship between evaporator face velocity, fan energy use and overall heat transfer coefficient (U).

The relationship between fan energy usage and pressure drop due to fouling (or any other blockage) is represented by Eq. (2):

$$W_{fan} = \frac{Q\ \Delta P}{\eta_{fan} \bullet \eta_{motor}} \quad \ldots\ldots\ldots\ldots(2)$$

Where

W_{fan}= Fan energy use (W);

Q= Volumetric flowrate of air ($m^3\ s^{-1}$)

ΔP=Pressure drop across facility (Pa);

η_{fan}=fan efficiency;

η_{motor}= motor efficiency;

Figure 2 indicates that increasing air velocities (by modifying the fan speed directly) will increase energy usage. Increasing the air velocity will also influence U, but at a decreasing rate and up to a maximum limit.

However, published research on the effect of coil fouling on HVAC systems (Blatt, 2006) indicates that a modest decrease in energy usage is to be expected in cleaned air-conditioning units with respect to clogged units. Some published results that back this view are below:

(1) A 5 to 10% pressure drop increased between 2 to 4% the energy usage. These results were greater for marginal and extreme conditions, e.g. units that were operating on a steep part of the fan curve or that had low refrigerant charge.

(2) Energy usage was relatively insensitive to low and moderate air flow reduction due to fouling. For example, an air flow reduced by 35% resulted in a 6% drop in energy efficiency.

(3) Substantial fouling is needed to produce a modest (i.e. 5%) degradation in energy efficiency.

Further, Yang *et al.* (2007) found capacity degradation of 4 to 5% for an 11 kW evaporator with fouling over one year. They also found that large evaporators are affected less by fouling than small equipment, due to the use of deeper coils with lower fin densities.

So, should I worry about dirty evaporators?

From an energy savings point of view, the rewards of cleaning evaporator coils are likely to be modest. However, if we extrapolate small energy savings to several cold stores/refrigerated trucks, cleaning evaporators to increase energy efficiency could be worthwhile. To fully assess the opportunity, cost-benefit analyses on specific equipment/sites would need to be performed.

From a temperature control point of view, a clean evaporator can lead to more homogeneous temperature in cold stores, because the cool air forced by the fan will not face obstructions and will distribute more evenly in the storage space.

Better temperature maintenance and control within a cold store is indeed a good thing. But there is also the benefit of avoiding contamination from the evaporator coil to food products: the Australian Cold Chain Food Safety Programs, which are a companion volume of the Australian Cold Chain Guidelines (1999), specify in Section 4 (Support Programmes) that a cleaning programme for businesses handling food in the cold chain needs to consider cleaning and sanitising in "chillers, freezers and other storage rooms, including the fan units in those rooms". Particular concerns are spoilage and food poisoning organisms (e.g. *Listeria monocytogenes*). Compliance with the ACCG is a requirement commonly requested by supermarkets to their suppliers.

References

Blatt,M.H. 2006. Advanced HVAC systems for improving indoor environmental quality and energy performance of California k-12 schools. A report for the California Energy Commission. P.7.

Evans, J.A., Russell, S.L., James, C. and Corry, J.E.L. (2006). Microbial contamination of food refrigeration equipment. Proceedings of the 13th World Congress of Food Science & Technology, 17-21 September 2006 Nantes, France 7 pp.

Yang,L., Braun, J.E. and Groll, W.A. 2007. The impact of evaporator fouling and filtration on the performance of packaged air conditioners, Int. J. Refrigeration 30: 506–514.

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