Large Chick Trailer

Background

Unitrans Freight and Logistics is a leading transport company based in South Africa active in a diverse range of transport and logistics activities. In 2010 Unitrans Freight ran some 2000 trucks, ancillary vehicles, and yellow equipment. Total operations generate 7 million km per month and comprise 64 contracts across South Africa. Unitrans Freight has five operating divisions, of which Foods Division (Foods) is one. Foods run 18 contracts and their vehicles generate 1.45 million km per month.

Specialised activities

A long standing client of Foods is the foremost poultry producer in the country. This producer operates three modern processing plants and manages vast poultry farms in several provinces producing over 4.5 million birds per week. All essential poultry production transport activities are provided by Unitrans Foods. This entails: feed deliveries, egg and chick transport, poultry loading and transport, muck out and litter removal, some bus transport, and certain other activities. A requirement arising from this long standing relationship was the need for three ultra large day-old chick carriers (coining a term **LCT** Large Chick Trailer) to handle the increasing demand from new farms, contract growers and long distance chick transfers. Approximately 3/4 million chicks are transported by specialised vehicles in different areas each day. This requirement prompted an overseas fact finding tour in May 2009, meeting with manufacturers, poultry producers, live animal transport specialists to identify best practices and concepts. The author's Membership of the Institution of Agricultural Engineers was invaluable in organising many of these meetings, with others arising from technical contacts arranged from South Africa.

Jim Ward of Unitrans Foods, and Mario Boshoff of Carrier Transicold jointly developed a semi-trailer with a number of special features to meet this requirement. Three such LCTs have since been built locally and commissioned, and this article concerns the design and development thereof.

<u>Day-old chick transport</u>

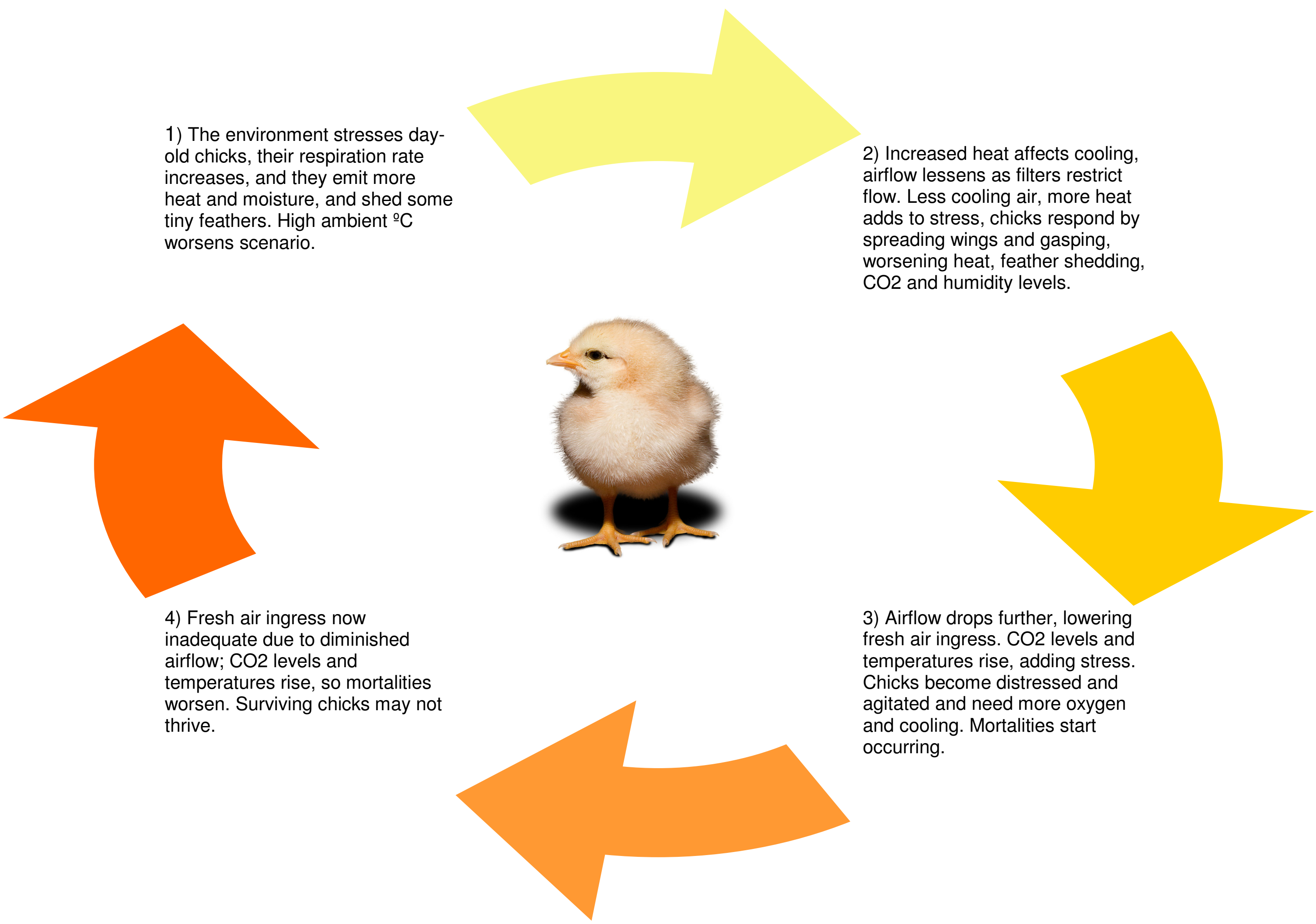
European and US transporters keep chicks warm in winter and ventilated in the summer, with emphasis on temperature control, using recycled air and powerful heating. Many vehicles have a heating ability only, and rely on cool ambient fresh air inflows.

In South Africa the emphasis is on cooling, avoiding suffocation or heat stress, and ensuring fresh airflow. Heating is required in winter when temperatures are often below freezing, however, this can be achieved by pre heating the load box. The main challenge facing long distance chick transport in high ambient temperatures is removing the heat emitted by the chicks themselves, and providing adequate (19.6%) oxygen supply at all times.

Previous chick transporters used recycled air, with overhead ducting blowing air down onto chick trolleys against natural thermals, and stale air drawn forward along the floor of the body, through filter screens, into a plenum (mixing) chamber and back via the refrigeration unit, to be cooled and then fed into the chick load again. The replacement of fresh air was intended to give a ratio of 30% fresh : 70% recycled.

Older truck showing overhead ducting with top down recycled air pattern.

Climate control is usually achieved by mixing recycled air with fresh, as this provides accurate temperature parameter limits; but for day-olds this system can also create problems. Filter screens may become restricted due to chicks shedding 'down', and this fluff gradually reduces airflow and leads to suffocation. It is difficult to control internal temperatures due to the chicks own heat output with restricted airflow and high ambient temperatures. Allowing more fresh air ingress makes temperature control difficult. In South Africa, coast to inland routes vary by as much as 1500 m in altitude, with significant climatic changes. On humid days there are incidents when coils begin icing, reducing airflow, and the unit switches to defrost mode, activating heater banks and inadvertently overheating the chicks. Under certain circumstances, recycled airflow systems can trigger a vicious circle –



Example of removable filter screens prone to feather clogging, requiring regular cleaning or replacement.

Unforeseen delays, where the first chicks to emerge are held back before loading may mean they are already stressed before loading. This information is not forthcoming, making it difficult to establish how long the first chicks are in holding areas.

An analysis of several years of loads with high dead on arrivals was conducted, and this showed that when there were significant deaths, these came primarily from a lack of fresh airflow, and *not* from a lack of temperature control. Previous emphasis was mainly on temperature management. Current chick and egg vehicles are fitted with a data temperature recorder, and temperature vs. time print outs are studied. Results show that transport DOAs do not necessarily correspond to temperature issues. In fact, suffocation causes most DOAs, not overheating or overcooling. Information obtained in Europe confirm these findings. This research forced us to be risk averse and objective in the initial design, with airflow perceived as more critical than temperature control.

<u>High mortality loads – some common elements</u>

Diminished airflow: blocked evaporators, blocked filter screens, slow fan speeds, fins bent over from high pressure washing.

Failed temperature controls: faulty probes, overcooling or heating, defrost cycles switching off fans, incorrect operation of emergency fans. No temperature indication in cab due to cable separation.

Excess CO_2: bird stress before or during loading, excessive stocking levels, inadequate airflow, high respiration rates, gasping, unit malfunctions.

Other: screen changes during long trips carried out *with the fridge running:* cause quantities of feathers and debris to bypass filter screens and block the evaporator coils, especially when the same screens need to be cleaned and refitted or have broken filter mediums. The complexity of the unit itself tend towards breakdowns.

There are also issues over which the carrier has no control:

Quality of stock, new vaccination types, chick strains, unidentified sickness in hatcheries, pre-stressed chicks etc. can cause DOAs after offloading. Such sensitive pre-load information is seldom divulged.

Whereas previously the primary goal was accurate temperature control, the LCT design shifted the emphasis to achieving airflow requirements, larger loads and only controlling temperature rise.

Design brief

The client wanted a semi-trailer capable of transporting 108,000 day-old chicks without undue stress, over long distances, in all seasons and regions. Internal temperatures were acceptable in a range between 18ºC and 37ºC as day-olds leave the hatchery at 37ºC. There was to be no recycled air. The trailer also had to meet or better three live bird transport requirements: 1) clients own historic specifications, 2) EU/HSA advisories for live chick transport, and 3) breeder requirements based on its worldwide distribution and transport of hybrid chicks. It proved impossible to completely meet the breeder specifications, which increased during the build programme, but the LCTs meet 91% of this standard.

Recommendation source and specification	Measure	Volume/time	Rateable
Clients	Airflow	44 M^3/hr	Per 1000 chicks
Clients	Air exchange rate	31.98 M^3/hr	Per 1000 chicks
US Breeder guidelines	Airflow	84 M^3/hr	Per 1000 chicks
US breeder	Air exchange rate	Minimum 20 cfms max 40 cfms	Per 1000 chicks
HSA/ European Union guidelines	Air exchange rate	30 total volumes/hr In this case 30 x 83 M^3 Gives 2490 M^3/hr	Per volume of load box.

<u>Heat removal problems</u>

The thermal load from 108 000 day-olds is around 40 Kw unstressed. Each chick emits between 0.3 and 0.4 watts. Measurements of exit air temperatures from fans confirm this. Heat load from 35 000 to 45 000 chicks in transit can be controlled with powerful air refrigeration units and recycled air, but not in very large loads. No mobile refrigeration unit in the country is capable of exceeding the heat load. For >100 000 chicks a system using recycled air was looked at but needed a pre-cooling unit to supply the main fridge unit, and this would have added to the cost and complexity. It was decided to use a total loss system without recycled air, employing the natural thermal movement rising from the chick trolleys. All air entering the vehicle would be fresh air, cooled and blown from the floor upwards.

<u>LCT airflow routing</u>

Cooled fresh air is blown from the unit into a 225 mm width false wall situated in the trailer front body; the air is then forced past curved upper and lower air guides (90º half moon profile) that direct the exiting air from the fridge unit downwards and horizontally into the false floor ducts with minimal air velocity reduction. Two splitters then guide airflow into three floor ducts. The cooled air passes along tapered ducts in the trailer floor at high velocity, and exits from 29 laser cut holes in the duct covers. Air then blows upwards between the lines of chick trolleys and roof, and side fans extract stale and heated air as it rises, creating a slight negative pressure inside the load box. Without recycling, there is no potential blocking of evaporator coils, or a need for filter screens. Air is drawn in through the unit and side louvers.

Specific design and application difficulties

1) Ensuring the air velocity and flow remain uniform over the entire length of the trailer body, to prevent 'dead zones' of inadequate airflow, or over supplied areas where day-olds would become too chilled. The ducting and hole design involved complex aerodynamic calculations for which we gained outsourced assistance.

2) Hole size. Because the ducts are tapered, the same outlet diameter could be maintained over their length. Early covers had to have hole sizes reduced to prevent loss of under floor air pressure. The trailer roof and sides are fitted with fifteen extraction fans, running constantly to extract stale heated air and CO_2. By removing all stale air the potential for suffocation is minimised. The fan capacities, hole sizes and spacing were balanced, although these dimensions proved difficult to calculate owing to the effect of air velocity losses in the false wall, making some of this exercise a trial and error approach. Final air volumes were tested and now emerge evenly along the length of the ducts.

3) Operational changes. Farms were accustomed to receiving smaller loads.
Delivering 100 000+ chicks per load meant that offloads took longer than usual. Neither the farms nor the hatcheries were geared for this, and at times chicks spent excessive amounts of time in the trailer; with the rear doors open, the fans then drew in hot outside air and any temperature control was lost. Changes made to operating procedures include partial opening of emergency hatches during offloads to offset this. Loading patterns were sequenced so that first chicks out of the hatchery would not be loaded first (into the front of trailer) but later, so as to minimise time in transit and avoid the first chicks hatched spending

the longest period in transit. At all times the client's key technical advisor was kept fully appraised of developments through a series of detailed design and progress meetings.

Main design specifications

The LCT (Large Chick Trailer) uses a high capacity Carrier Vector 1850 mobile refrigeration unit. Normally used on 15.4 M length insulated semi trailers this can maintain a 90 M^3 frozen load at -20ºC.

Maximum 5975 M^3/h flow at 0Pa static pressure.

High fan speed of 1793 RPM. Unlike mechanically driven fan units this is unaffected by the compressor load. This was a critical factor in selection.

Refrigerating capacity:

With entry air temperature at 30ºC and exiting air at 0ºC the capacity is 17 210 watts.

9 Kw of heating is available.

Power unit 2.2 L 26Kw Kubota diesel

A 670cc direct drive semi hemitic compressor.

Three phase Pratt & Whitney high capacity fans.

HFC R404A Refrigerant

Battery charger for emergency use. Factory settings adapted to eliminate defrost cycles, block lower set points, and allow continuous running on high power without cycling. These changes were done in consultation with Carrier SA and Europe.

Axial motor extraction fans

225 mm Ø

24 V motors, 1000M^3 airflow at a static pressure of 2.5mm (0.1inches H2O)

~ 3.6 Amps current draw

14 x fans positioned in roof and walls to compliment each other and avoid any "dead spots". They remove more air than the incoming volume, ensuring a constant slight negative air pressure within the load box. This increases airflow across the evaporator and improves the

fresh air supply. The vacuum effect is noticeable in that rear doors are difficult to open with all fans running. The internal negative pressure created is maintained between 2.5 and 5mm of H_2O.

Under floor ducting

Initial width 430 mm x 150 mm

Final width 100 mm x 150 mm

Hole diameter calculated to achieve positive pressure inside the duct and maintain high air velocities, whilst providing necessary airflow volumes.

Additional Booster fan

Airflow increased by an additional 1.5A/65Hz, 380V, 3822 RPM fresh air booster fan driven off the unit's generator, so mounted as to increase ducting airflow by 2 200 M^3/hr.

Airflows and velocity

Unit supply air velocity is at 6.5 m/sec, a flow of approx. 5600 m^3/hour + booster 2200 m^3/hr. Total calculated volume flow of 7800m^3/hr in total, 2600 m^3/hr per duct.

Theoretical extraction capacity from the fans is 14,000 m^3/hr running with unlimited air supply, but actual extraction measured under loaded doors closed conditions, is 8265 M^3/h.

Using the norm total volume flow = fan area x velocity

Fan area 0.0397 M^2 x 4.133 m/s avg. measured air velocity = 0.164 m^3/s volume flow/fan 0.1643 x 15 extraction fans x 3600 to convert into M^3/hr gives 8872 m^3/h total volume flow. This far exceeds initial required airflow, but in terms of the breeder recommendation only allows for loading 98 000 chicks.

Thermal Loading

Heat output from chicks is an estimate but was previously regarded as 0.24W per chick. This figure has increased over time, possibly due to breeding changes or higher metabolic conversion rates.

Carrier Europe use 0.3 W per chick.

South Africa, the standard generally is 0.4 W/chick.

Cobb Breeders 1 BTU/hr/chick

Many factors affect this heating effect, but in non-scientific terms, the thermal load from 100 000 live chicks is akin to switching on 40 x 1 Kw fan heaters/humidifiers at full power in a confined space. It is difficult to accurately replicate the heat and humidity of a live load of 100,000 chicks, and the mere action of entering a loaded box or opening doors affects the accuracy of readings and airflow patterns. Tests conducted using temperature increase/time in relation to volume and the number of chicks, showed an increase from 15ºC ducting to >29ºC exit temperature in a *similar* layout, and affirmed outputs of 0.315 - 0.4 watts/chick. For risk reduction the higher figure was chosen.

Heat load from a maximum load of 108,000 day-olds was thus estimated as 43 Kw depending upon ambient temperature and bird size.

On warm days, ambient air temperatures > 33ºC, the number of chicks carried is reduced to avoid excessive temperatures at the top of the load body. Maximum loads create load box temperatures that are very difficult to control. Controlling temperatures within a range of 3ºC from a set temp of 32ºC requires more volumes of chilled air than the fridge unit can produce. The LCTs have conveyed chick loads in 37ºC ambient temperatures and 100 000 plus loads in <35ºC. Unfortunately there have been significant DOAs in high temperatures when LCTs were stationary due to roadwork delays, and on trips that exceeded 24 hr duration, when flock restricted fans extraction rates. Ambient temp. exceeded 50ºC in one instance, stationary with radiant heat coming off the road surface.

Other features

For reasons of Bio Security, covers are removable for duct cleaning, and the internal fittings are either stainless steel, fibre glass or 3CR12 so that trailers can be fully washed out and disinfected after each load. Drain plugs are installed.

Tail lift

A Dhollandia DH-LSUA .40 cantilever was selected.

2300 mm aluminium platform with trolley stops.

2000 kg rating for high safety factor and durability.

The actuating arms and cylinders are non standard to accommodate the false floor height.

The platform offloads three trolleys at a time, and has a remote control. Offloading and loading is usually carried out swiftly.

Running gear

SAF Holland axles, tandem air suspension with lift and sink facility was chosen to facilitate offloading at different load heights.

8 x 12R 22.5 tyres on spigot mount 22.5" steel rims.

ABS brakes (drum) using Wabco 2s/2M twin line braking system.

SABS ECER13 brakes.

Jost KZ1008 king pin and A402 landing legs with swivel foot.

Chassis beams are 130 mm x 8 mm with domex steel top and bottom flanges.

Other

Elite Fibres Johannesburg fabricated the body, ducting, fan cutouts, cable conduit and fitted suspension, fridge unit, fans, wiring and tail lift installation were completed elsewhere.

Trailer body was built to supplied dimensions.

Polyurethane foam insulation medium sandwiched between white gloss GRP joint free skins for all panels. K value polyurethane = 1.3 kj/m2/cm thickness/C.

Coefficient of transmission (U) = 1.1 kj/h/m2/C

There is no facility to test a body's thermal rating in this country, however, road radiant heat and sun heat on external surfaces are significant factors.

Roof thickness 100 mm, walls 60 mm, meranti beams used in stress zones.

Floor 115 mm thick polyurethane foam, meranti and steel cross members with 150 mm deep false floor section to supplied dimensions.

Cover plates 3 mm 304 grade stainless steel.

3CR12 door frame with twin doors, double sealed with anti hijack escape mechanism.

18 emergency vents each side with external flip up covers.

Internal scuff plates set at heights to minimize shoring bar and trolley damage.

External dimensions 2.6 m width, 2.5 m height, 14.6 m length.

Internal dimensions 2.47 m width x 2.25 m height x 13.57 m length.

Designed to accommodate 32 chick trolleys, in eight rows, four abreast.

Internal volume approximately 83 m^3.

Pictures of floor ducting during fabrication. The uniform width is an optical illusion.

Ducting, steel cover removed.

Emergency vents on each side.

Interior looking aft, one door open.

Interior looking forward during build.

Preparing wall panels for signage.

Service hatch removed to show false wall.

fan cut outs for flush mount extraction fans.

Trailer rear with toe reveille to meet tail lift platform.

Rear drain ball valve for washing

Cut outs for cantilever tail lift

Safety features and risk reduction

The client required a number of safety features. Where possible these were met but it was impossible to make the trailer operate as a stand alone. Electrical power is needed from the truck for fans. It is also necessary to transmit and record live data while in use, so temperature probes were fitted linked to IGPRS and satellite data tracking, affording real time updates on conditions within the load box. In-cab warning lights indicate if any of the fans switch off. Fan power supplies are individually fused.

These trailers are conveying large chick loads with negligible losses. Previously, DOAs of below 0.5% were considered acceptable. The new LCTs are operating at 0,07% which is a significant improvement. They are currently in use.

Recent operating data from LCTs (Oct. 2009 to Nov. 2010):

Total number of loads	868
Total No. day-old chicks carried	58 503,809
Maximum load conveyed	105 ,600
Average load	67 401
Maximum ambient temp recorded	38ºC (one occasion)
Total DOAs over period*	0.07%

**16% of DOAs occurred in one incident, due to human error)*

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