APTEC Technology Consulting

Keywords: aerosols, ammonia, AptecApp, blast freezing, bleeding, blood, business model, carcass, chilling, compressor, computer App consumption, contamination, database, design, deboning, defeathering, disinfection, effluent treatment, evisceration, fire, flake ice, frost-heave, halal, hock, hygiene, killing, layout, LEAP Concept, machinery, manpower, maturation, microbes, offsites planning, packing, plucking, portioning, poultry, process description, power, refrigeration, rendering, resources, retrofit, RTC, RTE, safety, sandwich panels, scalding, screw chilling, services, slaughter, standards, steam, supplies, temperature, utilities, vacuum, vendor, ventilation, washing, waste water treatment, website, weight percentages, yield

Poultry Processing for Small Plants - Step by Step; Vendor Database

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Document dated 18 Aug 2005, Revision 6, dated 2 Oct, 2023

[This document contains the revised and updated salient text of (1) Poultry Processing step-by-step, (2) White Paper on Market Size, Prospects, Pitfalls and (3) New Processing Plant – FAQ, all of which were past uploads to this website earlier. In addition it contains linkages and references to the AptecApp, the free planning software which you can download from page "Tools" of this site and other articles uploaded from time to time and aimed at helping the startup entrepreneur in poultry processing and the vendor database, revised on 25 September, 2023]

1 The Product

The process produces fresh, hygienic chilled dressed whole chicken or frozen dressed chicken with skin-on[i]. Poultry products can be sent to the market for sale in returnable crates in shell or tube ice as fresh-chilled. Or the product, as it comes off the line, can be blast-frozen and sent to the frozen store for long-term storage, for sale as frozen poultry or freshly thawed poultry, as needed. Frozen products may also be presented in crates - individually poly-packed and shipped in vehicle mounted refrigeration equipment or in insulated containers with ice-pack[ii] product coolers.

During transit, display and in customers' refrigerators, fresh chilled products must always remain at between -1°C and +4°C. Frozen products, once they are brought down to frozen status in a blast or plate freezer, must always remain in that state – i.e. well below -10°C; preferably below -18°C. When stored at below -18°C, poultry has a shelf life of a year[iii]. Frozen poultry may also be thawed in small batches, to be sold and consumed on the same day as chilled product.

Depending on local market requirements, by adding inexpensive table-top disk cutters and doing manual deboning, or using a cone de-boner (which is an entry-level machine), it is possible for a processor to convert part of the produce into value-added items such as portioned chicken, curry-cut or deboned meat.

The project costing in the companion AptecApp (also available for downloading from this web page) assumes facility for blast freezing a part of the production and storage of the same and allows you to examine the relative financial implication of all these options for five project sizes ranging from 1300 BPH to 6000 BPH.

2 Business Models

Seventy years ago practically all chicken slaughter worldwide was done manually, often at the point of sale or consumption. This practice has been gradually phased out from most countries except some in South Asia and Africa. In India it is yet to be phased out and less than 15% of the poultry consumed here is still slaughtered by the roadside or in live bird *mandis*. But the processing capacity has been growing at 12.3% per annum from 2000 to 2020[iv] and it is my belief that very soon the government may announce the outlawing of street slaughter of poultry in the interest of public health and safety, economic sense and employment standards.

This practice of farm-gate sale of live birds for subsequent slaughter by the roadside or in *mandis* is called the wet market for chicken. Organized slaughter facility for chicken is preferred over wet markets because of obvious benefits to the environment, animal welfare, the industry and public health and the belief that rampant avian influenza and other diseases cannot be controlled unless wet markets are closed down worldwide, nor can the Indian poultry business be considered at par with the rest of the world in terms of hygiene and quality till this is done.

At this point you might ask - who ventures into chicken slaughtering? Historically four main categories of investors have emerged.

2.1 The first is the chicken farmer whose operations grow over the years and he eventually wishes to cater directly to the consumer instead of going through brokers and the wet market.

2.2 The second is the feed miller who is forced, from time to time, to buy out insolvent farmer customers and inadvertently finds himself having to market live birds.

2.3 The third category includes supermarket chain owners and managers of large establishments (such as the armed forces) who are unable to source slaughtered chicken in sufficient quantities, of the right quality, consistently over the year and at competitive prices.

2.4 The fourth category covers the merchant processors who own processing plants but do not have poultry farms. So they process birds for others. Merchant processing is a risky business model because such a processor has control over neither the backward vertical nor the market. However, in recent years ProTAC, located at Mulbagal, near Bangalore has pioneered this model very successfully and is increasing its capacity, first from the present 3000 BPH to 4000 and and then to 7000 BPH. Its principal customers are the home delivery segment like Amazon, Food Panda, Fresh to Home, Licious, Ola, Road Runners, Swiggy, Zapp Fresh, Zomato and others has emerged. Another merchant processor is Penn Foods in Maharashtra. More details are given in the bi-annual Industry Reports published on the Aptec website.

This Home delivery segment has emerged in the past decade as startups for perishables in the FMCG food sector. It is a retail marketing activity, often combining various types of poultry, meat and fish products under its own brand name, which it initially sources from established processors, slaughterhouses and mandis. It then portions, cleans, and packages the product for retail delivery. Later, when the market expands, it either sources from merchant processors or refurbishes and leases existing defunct local plants. Eventually home delivery companies hope to carve out opportunities within the industry as major FMCG marketing entities with backward integration down to slaughterhouses and farms.

3 LEAP Model Processing Plants

Except where general details of the poultry processing activity is discussed in this article, we will concentrate on the LEAP plant whose design is now promoted worldwide by Meyn Food Processing of Holland. This model was designed by Aptec in end 2011. It can be built with an initial capacity of 1300 BPH or 2500 BPH and can expand as required, to a larger capacity, say, 6000 BPH in steps.

This model requires initial designing of the master plan suited to the final capacity, which in turn depends on the size of land holding, market, constraints in supply of live bird and extents of the entrepreneur's growth plans. Once the master plan is drawn and approved, a sub-plan suiting 1300 or 2500 BPH is further drawn for initiation of work at the site, making sure that space allocation is in tune with the master plan and offers no obstruction to future growth.

The LEAP concept allows you to begin with a small building, thus reducing capital cost, with the ability to expand with only 2 days' shut-down. For more information on this you may refer to the LEAP Concept document which can be downloaded from the Aptec website. Be warned, though, that you cannot get the benefits of this design concept if you start with locally built, Bayle or Chinese machinery.

4 Land, Location and Layout

Poultry processing, no matter how small the capacity, requires a large plot of land and access to lots of water. Land is needed for the main slaughter plant, offal rendering, refrigeration, frozen store and administration, live chicken truck holding area (lairage), truck and crate washing area and electrical sub-station, all of which may be spread out on the plot and take up rather more than half a hectare. At least another half a hectare and preferably more area is set aside for wastewater treatment, aeration and settlement lagoons. Additionally you need to interact with your local pollution control department and understand the "red zone" concept and their rather fanciful conditions relating to "zero discharge" which is mandated by law in India. Finally, you need to recognize the fact that poultry processing has strong scale economies and therefore you need to keep expanding processing capacity to stay competitive.

The site should be located along an all-weather road and should have adequate use of treated wastewater for agriculture or else, subject to local by-laws, should be used for irrigation of your own land[v]. Above all, the site should have year-round access to sweet and uncontaminated raw water. The quantity ranges from 25 litres per bird at 1000 BPH capacity to 12 litres at 8000 BPH or higher[vi].

Given the choice, we would recommend that you locate the plant closer to farms than the market. So a distance of up to 30-40 Km from commercial farms is good. The market may be more distant - even a distance of 200+ km is quite operable. Other relevant factors are proximity to labour, distance from thickly populated areas and access to power and telecommunication facilities. Please also study the Hub and Spoke model which was described in the March 2021 issues of the Industry Report on the Aptec website[vii].

A word about government industrial estate and food-park land. Assuming that the land is priced right for all the infrastructure it provides (power, road, water and reduced red tape), it is imperative that there be an **existing common** wastewater treatment facility. The emphasis is on both words - **existing** and **common**. If it is not **existing** from the time you start operation, you will have to create your own facility, and if they have plans of **adding their common facility** "later on", then to make it viable, they will likely force you to scrap your own! Ultimately, these agencies need to grow out of their role of real estate agents and mature into industrial infrastructure providers. Till they do so, you are safer with greenfield plots.

Bottom line : if a government industrial estate has plans to **add** a common effluent treatment facility **later on**, their land is not suitable for this project.

5 Buildings

Two distinct construction styles are popular internationally, and the choice would depend on relative cost, functionality, fire-safety and convenience.

5.1 The first is an RCC frame building with brick walls with an RCC in-situ cast roof for the main process area, housing operations like hanging, killing and defeathering, evisceration and chilling; and a steel frame building with GI sheet roofing and PU sandwich panel walls and false ceiling for cold areas including portioning, deboning, packing, chilling and frozen storage. The rendering building is special, consisting of 2.5 or 3.5 floors and generally built for a large static load, therefore it must be of RCC frame, brick walls and RCC floor slabs[viii].

5.2 The second style is entirely based on PU sandwich panels, although even in such a plant it is preferable to use the RCC style for constructing the rendering block. Aptec does not approve of this second style of process plant construction as well as the antiquated single storey rendering plant layout peddled by some vendors[ix].

5.3 Some design companies who specialize in complex buildings prefer to use sandwich panels throughout for all their overseas assignments. Their choice is natural. But, to contain cost, construction activities ought to rely heavily on local materials and skills – soil, sand, gravel, timber, stones, rocks, etc and local craftsmen. These resources vary widely in specification from place to place and therefore the designer must have access to a knowledge base of their performance before specifying them. Overseas design companies mentioned above lack such local knowledge.

Therefore, When an overseas design company exports its designs and specifications, it finds it essential to standardize on one universal construction material, to reduce travel and other costs. His natural choice is sandwich panels. However, this model of designing buildings is not sustainable. Such overseas design firms ought to partner with local construction firms and leverage their local skills to benefit from a hybrid construction approach. Such an approach, whether adopted by an overseas designer or a local designer, is exactly what Aptec favours and promotes.

5.4 Aptec has placed five start-up layout drawings on its website. These are contained in the zipped file of AptecApp on the “Tools” Page. It has a detailed specification table for use by architects for preparing a bill of materials suited to Indian conditions. Download it and use it for your initial planning.

5.5 On June 3, 2013 a massive fire completely gutted the *Jilin Baoyuanfeng* poultry slaughterhouse in China, causing the death of 121 persons. Aptec researched the event and posted an article on its website pointing out the inherent hazards of designing the entire plant with sandwich panels. This is a popular and dangerous tendency among architects and entrepreneurs in the third world that can best be

described as “mental lethargy” or “Aping the West”. Similarly, in mid 2021, a plant under construction at Dharapuram, Tamil Nadu, was similarly gutted for committing the same mistakes. Fortunately it was under construction at that time and no lives were lost.

If you wish to avoid this fate, please visit the Aptec website and read the report - The Jilin Baoyuanfeng Poultry Processing Plant Fire.

5.6 In the October 2021 publication of the Industry Report a detailed assessment of fires in poultry, meat and food processing plants worldwide was presented by Aptec. This was part of the bigger effort undertaken by us to compile a handbook on design and construction of meat and more specifically poultry processing plants. This handbook is under preparation and from time to time Aptec hopes to place excerpts on the website in various issues of its Industry Report. The said section has been reproduced here from one such bi-annual Industry Report.

EXCERPT FROM OCTOBER 2021 ARTICLE ON FIRE HAZARDS OF SANDWICH PANELS

Processing Building - Construction Methods and Proneness to Fire Hazards

I have included this section on safety with sandwich panel construction following news of a conflagration that occurred at Dharapuram in Tamil Nadu in July 2021. Most people in the poultry processing industry know of this event but there is no reference to it on the internet. On talking to the owners, I learnt that the fire occurred when the machinery was not in operation. There was only a small lighting load on the cables. Yet the fire occurred and took down the entire sandwich panel structure.

Sandwich panels are designed for thermal insulation and their use should be limited to that purpose. In preferring to design poultry slaughterhouses in two parts – from arrival to screw chilling in brick masonry with RCC roof and the subsequent portioning, de-boning, packing, blast freezing and cold storage areas with sandwich panels and truss roof with drop ceiling, I have perhaps echoed the sentiments of IFBS Galileo[x] who wrote ”In recent years, insurers in Europe, for example in the United Kingdom, have increasingly been confronted by major damage due to fires where sandwich panels were evidently involved in the construction. As a result, these light buildings have come in for increased scrutiny from insurers.”

Do fires occur in poultry processing plants (which apparently contain nothing combustible and are often too wet to light up)? Yes, they do. We need to first admit this fact. To help you to accept this fact, we have compiled a short list of fires in poultry and meat processing and other similar food processing establishments where sandwich panels and ammonia gas refrigerant coexist.

Table 1 Some Recent Refrigerant Gas Related Accidents in the Food Industry

	Event	Probable Cause
1	3 June, 2013 at Jilin Baoyuanfeng Poultry Processing plant in Dehui, Jilin province, China. Facility completely gutted, 121 dead. (**I did a detailed analysis of this event and posted the report on my website - www.aptec.in. Later my article found use by British experts appointed by Chinese authorities in 2022 in arriving at the cause of fire)**	British experts identified electrical sparking in a toilet as cause and it lit up the sandwich panel construction.
2	27 June, 2013 Imperial Food Products chicken processing plant at Hamlet. The fire resulted in the death of 25 people and 56 injuries.	Hydraulic oil leaks into an oven, fire spreads in sandwich panels & embedded gas pipes.
3	14 June, 2015 the Tyson plant at Farmington Hills Ice Arena plant in Michigan, USA. Facility gutted. Workers evacuated to safety.	Power surge caused ammonia leak at relief valve
4	17 June, 2015 at Frigorio Allana in Ghaziabad, India. Packing buffalo meat. Facility gutted. 5 injured but survived.	Suspected ammonia leak, in association with sandwich panels
5	17 June, 2015 at Koch Food Plant at Montgomery, USA. Facility gutted. Workers evacuated to safety	Ammonia leak
6	15 March, 2017 at Katiyar Cold Storage for potato in Shivrajnagar, Kanpur, India. Facility gutted. 5 dead.	Ammonia leak, in association with sandwich panels
7	17 November, 2017 at Longyuan Food Co Ltd’s carrot packaging plant in Shouguang City, China. Facility gutted. 18 killed, 13 injured, 3 missing. There were many evacuation routes but none visible in the dark. "**The fire engulfed 100 metres of workshop in less than a minute**", Liu Fangping,	Ammonia leak, in association with flame retardant sandwich panels

	a migrant worker from northwest China's Gansu Province told Industryweek.	
8	28 January, 2021 at Foundation Food Group poultry plant, Georgia USA. The plant uses liquid nitrogen as a cryo-refrigerant. Facility gutted. Killed 6 and injured 12 before the premises were evacuated.	Nitrogen leakage displaced air and caused asphyxiation.
9	21 March, 2021 at South Pacific Meats in Awarua, Invercargill a Southland meat processing plant, New Zealand. There was full evacuation of personnel and no injuries were reported.	Ammonia leak possibly following a power cut - may have caused sparking.
Sources[xi]		

There may be three or more participants to fires in such premises. **First** there is ammonia gas. Ammonia gas often leaks from joints in valves and flanges, but since it is lighter than air, it tends to accumulate near the ceiling, But since it has a strong, distinct smell, people can detect a leak and take corrective action readily. Ammonia is itself combustible at a relatively high concentration and may therefore not be the primary agent in a fire. However once a fire is started resulting from an electrical event, panels can ignite and subsequently refrigeration pipelines exposed to high temperatures may leak large quantities of the gas and accelerate the conflagration[xii].

Ammonia is by far the most important refrigerant today. Hydro fluoro-carbons are no match for ammonia. But by the use of appropriate system design we can reduce all hazards related to it. In fact, as part of the new green energy initiative, bulk maritime transport of ammonia is considered a viable strategy[xiii] for transport of hydrogen as a fuel because hydrogen itself requires enormous pressure to compress into easily transportable tanks. As a chemical component of ammonia molecule, cost-effective transportation of hydrogen is a lot easier. So we need to learn to live with ammonia and master all safety protocols related to it.

Figure 2 Dense Black Smoke at Chinese Carrot Plant Fire *Source:* www.dailyexcelsior.com/18-killed-fire-accident-chinas-food-factory, 2 December, 2014

Second, there is the sandwich panel. There are two types of sandwich panels in use for thermal insulation. These are *polyurethane* type (PUR) in which a foamed layer of this material is sandwiched between sheets of galvanized steel or stainless steel. The other 'improved variety' is touted as possessing fire- retardant properties and carries a similar sandwich structure holding foamed *polyisocyanurate* (PIR) with an added fire retardant substances between steel or SS sheets. **Both types burn** – the fire-retarding variety in turn produces vast quantities of dense black smoke (see figure 2 – this plant had PIR panels) which causes asphyxiation and obscures exit signs in workplaces and corridors. Also, more importantly, when these polymers burn in limited air, they produce *methyl isocyanate* gas – the same that caused widespread deaths of over 1500 people in Bhopal in 1984.

Fire in sandwich panels can spread at a speed of 1.5 metres per second! See the eyewitness comment in event 7 in Table 1. In figure 4, I mention a simple retrofit implement of my own design to reduce loss from fire, personal injury and death associated with such structures.

Third there may be packing material consisting of plastic, paper or wood in the workplace. And **finally** there may be a gas or liquid fuel pipeline passing close to the sandwich panel structure.

Historic Plant Fires that led to New Standards

In table 3, I lay down a selection of procedures that ought to be followed in such constructions. They have been culled from the efforts of Tyson[xiv], who experienced a number of fires at their meat plants; the work of US fire department; emergency response teams; safety management experts; and finally an inspection and analysis of the Hamlet[xv] fire in the Loss Prevention Bulletin of 2018 summarizing the

events of April 2018 in a copyrighted article by the Institution of Chemical Engineers. They also take into account observations of Galileo Kreatives[xvi] and US Alliance for the polyurethane industry[xvii]. Here is an account of some of these fires.

The Hamlet chicken processing plant, operated by Imperial Foods in the town of Hamlet, North Carolina, USA, was located in a single-storey brick and metal building that was eleven years old and had been modified from an older building going back to early 20th century. The fire caused 25 deaths and 56 injuries. Following this fire, the company never recovered.

Almost at the same time a fire occurred at the Tyson Foods turkey plant in Little Rock, Arkansas. All workers were evacuated within minutes without any loss of life or limb. The difference lay in the fact that "the Hamlet plant did not meet safety standards and dodged inspections", while the Tyson plant incorporated full safety measures, complied with standards and followed GMP. Those who wish to examine the contrast between the two plants may refer the US Fire Administration Report on the subject.

Because a large number of PUR/PIR constructions exist in the broiler and meat industry today, many of which may have been constructed without complying with proper standards, I believe they need to make corrections where ever possible. I have listed the fire-safety standards to be followed when working with sandwich panels. And later in this article, a retrofit device to correct one of the most important defects in existing sandwich panel constructions.

Table 3 A Summary of Important Rules to Follow With Sandwich Panels and Ammonia Refrigeration		
1 Planning Stage		
1.1	Planning adequate and sensible exits. [Exit routes are divided into (a) exit access, (b) exit (route) and (c) exit discharge].	Exit access and exit discharge shall not be lockable from either inside or outside.
		Emergency exits access shall consist of easily shatter-able glass pane, and for shattering the same a hammer shall be provided at a convenient location near the door.
		Exits routes consisting of corridors leading to exit discharge shall be a minimum 720mm wide & 2300mm high and shall not be obstructed by stored material.
		Exit signs shall be in local language(s) + English + pictogram on exit access.
		Exit signs shall be lit by a self-contained power supply, so that outage of power lines do not cause the sign to blank out.
		Exit signs shall be at both the top of the door and the bottom. With the use of PIR panels, billowing black smoke hangs close to the ceiling and obscures signs close to the ceiling. See figure 2.
		Every workplace or room shall have two exits, preferably placed at opposite ends of the workspace. Doors shall be side hinged, swinging out of the work place.
1.2	Planning fire blocks	Fire blocks may be required in the design of certain concealed spaces, and at penetrations into pipe chases and ventilation shafts.
1.3	Planning RTE areas	Polyurethane should not be used in areas immediately adjacent to or above combustion equipment (such as furnaces and chimneys), high temperature process equipment or piping.
		Where open flame cooking is to be done, such as in commercial fryers, ovens, woks etc, the space shall be separated from urethane foam structures by a masonry wall/thermal barrier that can contain flames for a period of 2 hours
2 Installation or Construction Stage		
2.1	Safety during storage and construction	Foam board-stock shall be stored at construction site in limited quantities, in divided lots, in accessible locations, free from ignition hazards, with fire alert & water spraying system.
		There shall be no welding or metal cutting in contact with these foams.
2.2	What is permitted	PUR or PIR foamed-on-site foams may be used to fill cavities within masonry walls or under grade-level concrete floors. Such foamed-on-site polyurethane chemicals should be mixed and applied only by applicators trained in their proper use and familiar with their limitations.
3 Interaction With Other Systems for Safety		
3.1	Refrigeration Piping	Within the workspace all pipes/fixtures carrying ammonia shall be of welded construction only. Any fixtures requiring flanges being bolted shall not be allowed inside the workspace.
3.2	Ammonia sniffers	Are required in all work areas where ammonia is likely to spread in the event of leaks
3.3	Open flame in cooking equipment	Such sections shall be housed only within masonry enclosures or rooms (thermal barrier). The masonry enclosure shall be able to withstand and contain a fire for at least 2 hours, not letting it spread out of the enclosure.

3.4	Sandwich panel roofs	Shall not support electrical power or signal cables directly because when so supported, in the event of a fire, these cables burn rapidly and cease to function. Since these cables may be part of the fire safety installations such as emergency lighting, alarm system, fire and smoke sensors, emergency exit signs on doors, etc, they will fail in the event of a fire and not be able to perform the function they were intended to. If cables are required to traverse above a sandwich panel roof or drop ceiling, they may be supported clear off it, by trusses.
3.5	Thermal Barriers	Building codes may require foam insulation to be separated from the interior of a building by an approved thermal barrier such as 13mm gypsum wallboard (drywall). (Although some PUR/PIR panels have earned approval without thermal barriers through fire tests such as ANSI/UL 1256, FM 4450, UBC Standard 26-3, FM 4880 and DIN 4102-2).
		Where thermal barrier conditions prevail, thermal barriers are required both above and below the panel for suspended ceilings. This makes them unsuitable for wet processing plant areas because kraft paper liners on gypsum boards attract fungal infestation in humid or wet conditions and should not be used.
3.6	Sprinklers	In many cases, type of occupancy and type of construction also may require the addition of sprinkler protection and/or smoke detectors. Sprinklers are required except in wet areas. Walk-in coolers or freezers of less than 400-square-foot (37.16 SqM) area are considered fixtures and do not require sprinklers.
4 Orientation and Training of Personnel		
	Training, Drills	All personnel to be trained about emergency response, and periodic fire and disaster response drills done to orient them.

If you undertake such construction jobs, make sure that you follow these rules. If you are an insurance company, make your policies conditional upon your insurer, his contractors, sub-contractors and suppliers following them. And if you are an entrepreneur setting up new facilities which use these materials, make sure your efforts nurture, protect and save your employees instead of creating death traps for them.

Retrofitting Threaded-through Nipples for Cables Through Sandwich Panels

When lay fabricators work with PUR and PIR sandwich panels, they amply display their ignorance of safety standards that are essential for working with these materials. For instance, all such construction requires one to pass electrical cables through panels. The sloppy approach is to drill a hole and thread the cables through the holes thus drilled. Such an approach is dangerous.

Prepare a pair of disks from 2 mm SS sheet. Outer diameter 75mm, inner 25mm. to suit such a cable hole through a 60 mm thick panel. Of course, you will alter dimension as required for the cable hole and panel width. Three small holes are for self-tapping sheet metal screws.

Cut a length of SS tubing of 128mm length (for 60mm thick panel), OD 25mm.

Split the tube lengthwise to have a semi-cylinder of that length with finished, de-swarfed height of 12.5mm. Then cut it into 2 lengths of 64mm each. Due to the width of the saw, you will get only one proper piece per cut.

Weld each slit tube to the disc as shown. Clean surfaces and file down edges and swarf. Then push the nipple into the hole from each end. The key slot will face up on one side and down on the other. Then screw down the jigs into the panel from each end.

Figure 4 How to correct wired-through holes in sandwich panels to prevent fire risk. The half cylinder sections of tubing and key slot in disk shown here is meant for retrofitting the safety fixture. (Don't be extra smart – you cannot split a tube into two usable semi-cylinders and still ensure a wired-through nipple which shall keep spark and polymer separate !).

When you drill through panels, the steel cladding develops sharp edges and retains drilling swarf. As you pull cables through, the cables are stripped off and with vibration and small movements shorts can occur sooner or later whether heavy or light currents surge through them. Then the spark may set alight the insulating polymer. So if you are about to begin construction, run wires through SS sleeves. If you have already built, without using a sleeve, use the retrofit described in figure 4.

END OF EXCERPT FROM OCTOBER 2021 ARTICLE ON FIRE HAZARDS OF SANDWICH PANELS

6 Functional Sections

All modern process houses have a high degree of automation. But at some time in their past they started at more modest capacities, using a semi-automatic process. In industry parlance, a semi-automatic plant refers to " a high degree of automation in all areas except evisceration which is almost entirely performed by personnel using pneumatic hand tools". Therefore a fully automatic plant means one in which even the evisceration (EV, consisting generally of 7 machines in India) is automated.

Full automation is necessary where the **line speed is high or for which suitable manpower is hard to recruit**. At high speeds human operators holding passive or pneumatic hand tools are unable to cope. Semi-automatic plants can be expanded and upgraded by the addition of automatic evisceration machinery as they grow and the capacity warrants it. By my experience, the inflexion point is reached at 4000 BPH. Below that capacity semi-automatic plants perform well, above it, the speed may become too much for manual evisceration and automatic machined are deployed.

There is absolutely no truth in the assertion that hygiene and quality are possible only in fully automatic plants. This belief probably owes its origin to enthusiastic over-sell by equipment sellers.

The processing line consists of the following machines/sections. In this listing, machines required for both small and large plants as featured, together with an indication on technological trends and whether or not they are modular in design.

Table 5	**Steps in Poultry Processing & Required Machines**		
	Department/Action step	**Comment**	**Technology Status, cost***
1	**Lairage**	The ideal operation needs no lairage. Size depends on plant capacity and travel time between farm and slaughterhouse. Feed withdrawal is done at the farm: so ignore holding time as a design factor. But cater to thirst with fogging and fans.	Strong Evolution
2	**Mode of transport of live birds**	Design varies by type of live bird containers used, which in turn is influenced by operation size and stunning method applicable in your country or chosen by you. Small & medium sized plants in South Asia use coop transport, electric stunning at > line frequency and linear hanging arrangement. To cater to gas stunning, carousel hanging needs extra space at this end.	Strong evolution. in live bird hanging system. Modularity with steps of 1000 BPH. Proportional
2.1	**Arrival, stunning & hanging**		
2.2	**Electric stunning**		
2.3	**CAS stunning**		
3	**Killing & Defeathering Department**		
3.1	**Overhead killing line conveyor** with shackles, drive and lubrication system	In very small plants killing and evisceration may be combined in a single line (ref bundled layout with AptecApp) which shows an acceptable, cost-effective compromise LEAP layout design for low line speeds.	Modular. Not much evolution. Proportional
3.2	**Water bath stunner**	Various types of stunning exist worldwide but in India electric stunning at >line frequency is favoured. If stunning is skipped for religious reasons, as in Pakistan and Sri Lanka, strenuous flapping results in a 25% wing damage. Consult Islamic Fiqh Academy (Joga Bai, Jamia Nagar, Delhi), which advocates stunning in India. Select model to suit your final capacity – machine can be adjusted to line speed	Not modular. Evolving. Choice of model unaffected by capacity
3.3	**Blood trough**	A stainless steel modular trough - design drawing can be provided by Aptec.	Modular. Proportional
3.4	**Jacuzzi or Jet Stream scalder**	Local machines under-perform in comparison with Jacuzzi or jet stream scalder. Steam scalder was a failed innovation. Temperature control is the key to performance. Other design variations are (1) two and three pass arrangement, (2) steam or electrical heating, (3) direct or indirect heating and (4) scald time. Prefer two pass, indirect steam heating and between 80 and 120 seconds for jet stream and jacuzzi types respectively.	Modular design, cost & expansion in steps of 1000 BPH. No design evolution.
3.5	**Feather plucker**	Local and Chinese machines tend to underperform. A feather conveyor belt under the plucker is not essential – a floor gutter is enough to carry away feathers in the form of a slurry. Drum type pluckers are not used in India.	Modular - add machines of 1300 or 3000 BPH. No evolution.

3.6	**Head-puller**	For efficient evisceration it is necessary to pull off, rather than cut off heads. Simple design – no need to evolve.	Cap limits for models.
3.7	**Hock or foot cutting**	Hock cutting is standard in India. Where a combined killing-EV line is offered, the hock cutter is placed at the end of the line - after evisceration. But if separate killing and EV lines are installed, it exists at the end of the killing line.	Capacity capable of up to 5000 BPH. No evolution.
3.8	**Hock unloading**	Basic model suits capacities of up to 4000 BPH and design is dependent on type and source of killing shackles.	No evolution
3.9	**Chain & shackle washer**	Essential for product hygiene. More so in a combined line	Suits all line speeds
3.10	**Orientation**	Orientation in this and logistics in subsequent departments depends on your choice of two or three pass whether you use a two pass scalder as hock cutting & unloading positions are diametrically different for the two.	-
4	**Evisceration Department**		
4.1	**Re-hanging**	Fully modular down to 2000 BPH steps when manually performed. Can be automated cost-effectively beyond 6000 BPH, at which time the re-hanging machine takes over function of hock cutter	Modular, with proportional cost down to 2000 BPH steps
4.2	**Overhead EV line conveyor** with shackles, drive and lubrication system	Offered only where a combined line is not. Shackle pitch of 12" and 6" are possible when you use some automatic machines at half their rated capacities.	Modular. Not much evolution. Proportional
4.3	**Evisceration trough or belt.**	In semi-automatic evisceration the action is performed with the use of pneumatic tools over this trough/belt. If you choose trough, it can be locally fabricated to Aptec design	Modular. No evolution. Proportional
4.4	**Hand Tools (for evisceration in small plants)**		
4.4.1	**Pneumatic vent drill**	Pneumatic tool for cutting around cloaca without damaging the bursa and without spilling contents of the gut into the body cavity.	Not modular. To expand add machines, resulting in proportionality. No evolution
4.4.2	**Pneumatic, vacuum lung pistol**	Pneumatic tool for removal of lungs and tissue debris from the body cavity	
4.4.3	**Gizzard peeling system**	Removes the horny yellow skin lining the inside of the gizzard	
4.4.4	**Pneumatic neck cutting scissors**	Used only where the customers wants carcasses with neck off. Not common in India	
4.5	**Automatic Machines (for evisceration in larger plants)** For all these machines except 4.5.1 there are different models that allow you to operate at their 100% or 50% rated capacities. Then there is partial price proportionality		Partially modular, partially proportional
4.5.1	**Carcass washing system/**Automatic inside-outside washer	Outside washing spray cabinet, locally fabricated to Aptec design for small plants. For larger plants automatic inside/outside washers are necessary.	No evolution
4.5.2	**Automatic crop removal machine**	One of the automatic evisceration machines which does a more thorough job than manually possible. Aptec recommends it from 2000 BPH onwards.	No evolution.
4.5.3	**Automatic vent drill machine**		No evolution. Marel's combined action model is promoted in developing markets
4.5.4	**Automatic opening machine**	Different models to suit different processing styles. Meyn offers different models exhibiting different opening actions.	
4.5.5	**Automatic evisceration m/c**	Two styles exist – spoon type and hinged type with varying performance results. Different sizes to suit different speeds	Not much evolution
4.5.6	**Giblet harvesting machine**	Several automatic and semi-automatic models available from all vendors. Performance & yield depend on farming methods.	
4.5.7	**Automatic neck machines**	Models for processing carcasses with neck and neck skin removed available. Irrelevant for Indian market	
4.6	**Chain & shackle washer**	Essential for product hygiene.	Suits all line speeds
5	**Chilling Department**		
5.1	**Spin chilling**	For rapidly cooling carcasses cost-effectively for good shelf-life, far exceeding results from slush ice tanks. Local machines generally ignore counter-current flow and have poorer performance. Available in steps of 1000 BPH	Modular. Cost is almost proportional
5.2	**Air chilling**	Less cost-effective than spin chilling. Not used in India	-

5.3	**Dewatering or dripping system**	Small plants use locally made drip racks, progressing to spin extractors from Marel. Where weigh-line is installed, Aptec prefers extending it for automatic dripping.	Modular. Mature. Proportional cost.
6	**Weighing and Grading Department**		
6.1	**Rehanging**	Convetor for this can be locally sourced	Proportional
6.2	**Table top electronic weighing machine**	For manual weighing and grading of portions, whole carcasses, and tray packs	Modular. Proportional. Not much evolution
6.3	**Automatic weighing/grading line or machine**	Computerized , highly accurate weighing/grading for batching into 8 to 32 weight categories. Less accurate batching possible with cheaper belt graders.	
7	**Secondary Processing and Packing Department**		
7.1	**Packing table**	SS tables locally fabricated to Aptec design. To be used for portioning, deboning, grading and packing	Modular, mature, proportional
7.2	**Carcass bagging**	Used for wicket bagging whole carcasses. Bagging horns for small capacities and semi-automatic bird bagger for the rest..	
7.3	**Disk cutter**	Locally made machines for curry-cuts, portioning carcasses	
7.4	**Cone deboner**	Versatile machine for producing large quantities of portions and breast fillets with throughputs starting 700 BPH.	
7.5	**Japanese cut-up or J shackle line**	A larger and more efficient system than the cone deboner for capacity of up to 3000 BPH.	
7.6	**Cut-up, deboning, deskinning**	Several models available from all vendors. Only a few such systems in use in India because of their lower yields. Cheaper local manpower generally offsets their advantage. At higher end, combination of compact cut-up systems with cone deboner and Japanese cut-up lines is suitable for India	Partly modular, Evolving, Not proportional
7.7	**Packing**	A large variety of tray-packers available locally	Proportional
8	**Auxiliaries**		
8.1	**Offal handling**	Processing waste removal as slurry via floor-gutter system is suitable for India. Neither machine is available locally. Pumping and filtration equipment with gantry mounted pipeline to rendering block is preferred. Manual handling of offal is undesirable	Not modular
8.2	**Crate washing**	Two coop sizes are used and matching locally made machine must suit coop size. Automatic crate washing reduces manpower and ensures consistent and hygienic operations	Not modular.

NOTES
* This columns provides information about technology status, modularity and cost implication on expansion.
Mature/evolving whether the technology is undergoing change or is **evolving** and if so whether changes in technology during the expected life of the plant you are planning must make note of this in terms of changes in space need, processing parameters etc. Where it says **Strong Evolution**, you need to educate yourself more on the subject and make your layout amenable to future shocks within the useful life of your plant.

Modular whether design of the machine or system allows you to implement changes as your capacity grows or whether with changes in capacity you must scrap existing machine and opt for a newer, higher capacity machine

Proportional whether modification to meet increased capacity objective results in roughly proportional cost implication.

When you face a dilemma about space allocation to cater for evolving technology look at the five sample layouts bundled with AptecApp, where areas are specified. Further, if you are not familiar with the footprints of machines in the illustrations in this chapter, examine the layouts bundled with AptecApp. In it each machine footprint has a number that links it to a legend.

7 Description of the Slaughtering Steps

Trucks bringing live birds from nearby commercial farms are carefully scheduled to ensure steady supply, with movement commencing in the relatively cooler early morning hours.

Birds arrive preferably in top-opening plastic crates which are removed from the truck and loaded onto a terrace or veranda. From here a person carries the crates to the hanging man, who flips open its top lid and, withdrawing the birds, hangs them by their feet onto the moving shackles. One person can comfortably hang a thousand birds an hour provided birds are presented to him in such crates on a roller conveyor. For up to 1000 birds an hour a roller conveyor is useful but not essential. At small

capacities a linear bird hanging arrangement is Ok, but at higher capacities, like 8000 BPH upwards, a carrousel manual hanging station works better. At higher capacities, generally above 6000 BPH, bird coops are not favoured and cages holding dozens of birds each are used. Also, if gas stunning is used instead of electrical stunning, other methods of bird harvesting and transport may be employed.

Because these variations in bird arrival, stunning and container washing impose different demands on workspace, for a plant design capable of expansion or modification at a later date, the initial layout design must consider all these variables

7.1 Hanging and Killing

In under a minute the hung birds pass into a water-bath stunner. Here their heads dip into a small pool of water where they experience a mild electrical shock which stuns them. After stunning they may be killed by the Muslim ritual halal method or by any other manual or mechanical method. In small plants manual killing is preferred as it is cheaper and in many instances mandated for religious reasons. This is performed while the chicken are in a stunned condition. Here again one person can comfortably kill a thousand chicken an hour. Chicken are allowed to bleed into a bleeding trough for approximately 180 seconds (in case of manual killing as in Halal) during which time they lose approximately 50% of their blood content. This is the maximum amount of blood that they can lose – whether you perform halal or kill them with mechanically.

7.2 Scalding

After this the birds are scalded. The scalder is a bath of water held typically at +57 to +58^{o}C into which the birds are dipped. This temperature is suitable for hard scalding. Facilitated by a powerful air agitation of the water in the scalding tank (or a jet stream as in Meyn Jet Stream scalder), the feathers are soaked loose. Scalding has a great influence on the result obtained on plucking and therefore on the quality of the final product. Depending on the temperature setting and duration of scalding, the birds may be *hard-scalded* or soft-scalded. Hard scalded birds are suitable for blast freezing while soft scalded birds are generally better sold fresh air-chilled. In Asia hard scalding is universally preferred. For a detailed technological comparison and capital cost implication on the choice between these scalding methods, please contact us.

Scalding is THE KEY STEP determining bird quality. Good scalder uses precision controllers to stabilize temperature with better than 0.2 degree centigrade variance from the set point !

When using hard scald method it is essential that the line does not have to stop for any reason. At any given time (depending on the line speeds the scalder is designed for), 13 or more birds may be in the scalder. If they stay in hot water for even a minute in excess of the prescribed upper limit of 2 minutes, they get ruined.

7.3 Plucking

Scalded birds are moved by the overhead conveyor to the feather plucker. The plucking operation is performed by passing the birds, still on the shackle line, between pairs of rapidly spinning discs, each having several flexible rubber fingers pointed against the bird. Assisted by a small spray of water, plucking fingers develop enough adhesion with feathers (which have been adequately pre-loosened during scalding), to cause them to be removed. When comparing pluckers, note the total number of plucking fingers rather than the number of plucking disks.

Plucked birds then pass over the head-puller. Here the heads are pulled off the birds as they pass overhead. If the killing operation has not damaged the trachea, it gets pulled off along with the head. Else an additional person is required for removing it along with the crop after the evisceration operation. At above 2000 BPH it is economical to automate the crop removal part using an automatic cropping machine.

7.4 Evisceration

Most of the evisceration operation is performed over an evisceration trough which is made of stainless steel and provided with wash stations, tool holders and running water to carry away the offal. Alternatively the operation is done over a broad belt. The trough or belt carry away the offal towards a drain or a collecting vessel while operators perform evisceration steps on carcasses moving above.

In plants that lack an automatic cropping machine, a pair of persons located at the front end of the evisceration line perform a manual crop removal operation. The first of these cuts a longitudinal slit along the throat. The second man, using a small hook, pulls loose the trachea and crop and manually extracts them. In some cases removal of trachea and crop is performed manually as the last step in evisceration.

The next step in evisceration is performed by a vent drill which is a pneumatic tool. With this a tubular knife makes a circular cut in the abdominal wall around the cloaca and while the tool is being withdrawn, pulls out the disk of flesh along with the *bursa fabricius* and the large intestine attached to it. In this action, none of the content of the gut is spilled into the body cavity, nor is the bursa damaged. Consequently it is an important step in the hygiene and quality of the final product. A skilled operator using one vent drill can eviscerate two thousand birds per hour.

As the bird passes to the next operator, using an opening knife, another operator enlarges the circular cut. The next person pushes in an evisceration fork into the enlarged hole to scoop out the entire pack consisting of the intestine, liver, heart, gizzard and gall bladder and lets it hang over the back of the bird. After this one person each removes the heart, liver and gizzard. These then follow a separate movement path. The first two are immediately washed and sent for chilling. Gizzards are split, their contents washed off and their inner horny skin peeled off using a gizzard peeler. At 2000 BPH it is economical to automate the gizzard handling operations by the use of appropriate automatic machinery.

The washed and peeled gizzard then joins the other edible offal (heart and liver) for packing either into trussed birds or sale as separate items according to local market requirements.

The lung sucking pistol is positioned towards the end of the evisceration section. It is used by an operator to remove the lungs and any other debris, by application of vacuum. One person can use the lung sucking pistol on 1000 chicken per hour.

If the dressed whole chicken are to be sold with neck off, then one person positioned along the line uses a pair of pneumatic scissors to chop off the necks. Also depending on local conditions the neck skin might need to be cut off. This is done manually with a knife. These operations can also be done after the birds leave the evisceration trough.

7.4.1 How Much Automation Exists in EV in India?

In a processing plant in South Asia, a total of 7 automatic machines deployed in the evisceration department makes it "fully automatic". These machines are (1) vent cutting machine, (2) opening machine, (3) eviscerating machine, (4) giblet harvesting machine, (5) cropping machine, (6) final inspection machine and (7) inside-outside bird washing machine. Neck breaking and neck skin trimming are not relevant to processing for the Indian market. Here is the tally in India:

Table 6 – Automation of Evisceration in India (circa 2022)

	Level of "Automation"	**Operating and planned plants in India**
1	Plants with 4 or more machines (including plants with "multipurpose **" machines which perform all or many of these 7 actions)	Shanthi, SKM, Sneha, VH Davangere, VH Taloja, Godrej Taloja, Godrej Hoskote, Sivasakthi. (The last three, being Marel, use less than 7 automatic machines**)
2	Plants with 1-3 automatic machines	Approximately 17 plants in Table 1, part A of October 2022 Industry Report.
3	Plants with no automatic machine at all	All remaining plants in table 1, part A of October 2022 Industry Report including all indigenous plants

		of Deccan Automation, Dhopeshwar, RND, Storm Engineering and those of Bayle
*** Marel plants in India and much of the developing world contain several examples of such combined operation machines*		

The phrase "touched by hand" in itself can scarcely be treated as a pejorative. Worldwide, even in those plants that have automated with a vengeance, human contact occurs. Not just in the dirty and unpleasant departments that perform scalding, defeathering and evisceration, but most definitely, also in the post-processing stages such as portioning and de-boning, packing, inspection etc. – stages after which the product cannot be washed or disinfected any more! This is the irony of the pejorative associated with "touched by hand"!

Objectively speaking, the purpose of automation is manifold – to increase speed, reduce cost, perform tasks in unpleasant or hazardous environments, eliminate error and, finally, to increase hygiene. Any attempt to project the single agenda of hygiene at the cost of other factors is misleading. I believe it is of equal importance not to blindly assign a quality trait to level of automation. Unfortunately companies tend to use the phrase "fully automation" falsely as a kind of seal of quality. In a partially automated plant, it is also vitally important for the customer to note whether the first three functions are automated or the last three functions are. Automation of the first three functions does virtually nothing to improve product quality, whereas the last three functions are vital for improving product hygiene.

Full automation of evisceration becomes a necessity beyond the line speed of 4000 BPH. Below it, and at it, full automation may be gainfully avoided without any ill effect, provided skilled labour is available and labour productivity permits it. However, paradoxically, there is now a well perceived creeping shortage of labour in India, as there was in China half a decade ago.

In making comparisons, it is useful to remember that the daily wage of a process plant worker in Holland in 2002-03 was 127 Euros as against just under 2 Euros in India at that time. This is a sound reason why semi-automatic operations still make sense in the third world and why the bulk of the poultry processing done in the developed West needs to migrate to the third world.

7.5 Bird Washing

Birds are passed through a locally fabricated outside-chicken spray wash. At 2000 BPH and above it is economical to use the more efficient washing option of the automatic inside-outside bird washer.

7.6 Hock Cutting and Unloading

After washing, carcasses are dropped into the spin chiller by cutting off the hocks (using pneumatic hock shears in very small plants or using a hock cutter in 1000 BPH upwards capacities).

In very small plants it is usual to position another person along the line to pull off the remaining hocks from the shackles. At 1000 BPH upwards, it is usual to automate this step by using an automatic hock unloader. The line then passes through a shackle washer.

In plants larger than 1000 BPH, it is usual to split the overhead conveyor into two parts - one each for the killing and evisceration areas. In such instances the hock cutter is positioned at the end of the killing line and the birds are re-hung manually onto the evisceration line by their hock joints.

7.7 Spin Chilling

Depending on line speed, carcass size and cooling water temperature, to allow the carcass to experience a dwell time of approximately 25-30 minutes in the screw chiller, an appropriate chiller size must be chosen. Later, as your processing capacity increases, you add extra lengths. The screw chiller passes carcasses through a counter-current flow of chilled water, assisted by compressed air bubbling in the water to allow improved contact with the carcass, chilling of the carcasses is done till they are approximately 6 degrees C or lower. The spin chilling action also performs a thorough internal and external washing of the birds. Approximately 2.5 litres of water should be used per kilogram of carcass.

Water is pre-chilled to as close to freezing point as possible, and depending on line capacity and spin chiller size, sufficient quantity of flake ice may be added to the water to assist rapid chilling.

Quality of carcass can be retained only if thorough chilling is done AS SOON AS POSSIBLE after killing. It is therefore essential to have as low a water temperature as possible in the chiller. It is also important to note that if the weight of carcass doubles, given the same conditions, you would need four times as much dwell time to achieve the same degree of chilling.

You cannot recycle the water in a screw chiller. Doing so goes against some very sensible processing standards. The concept of red water chillers is fundamentally flawed and Aptec does not recommend it.

An estimated 50% of the production from the processing industry uses inadequately powered blast freezers for freezing the product. In fact these blast freezers are nothing more than souped-up frozen stores. Consequently freezing of a batch in such freezing chambers gets completed in as many as 10-18 hours. I have found it practically impossible to educate the industry about the damage slow freezing causes to product quality[xviii] - the capital cost difference between a well designed blast freezer and a souped-up frozen store is so large that short-term commercial prudence always overrides reasonable discourse.

7.8 Dewatering, Weighing and Batching

After chilling, birds are automatically unloaded from the chiller by its integral windmill unloader. The next action is to remove excess water. In small configurations, which do not aim in the foreseeable future to go in for automated weighing and grading using a computer system, a spin water extractor called a rumbler is used. Else a drip line is installed which can later be retrofitted with equipment for weighing and grading using a computer. In very small operations it is also possible to extract excess water by manually tumbling birds onto drip racks or tables.

7.9 Offal Handling

Approximately 24.5% of the chicken's live weight is discharged as offal during killing, plucking and evisceration (assuming heart, liver, gizzard and neck are retained as edible giblets on or in the carcass during these operations). The remainder, excluding blood, are dropped as offal, which flows as slurry in the floor gutters and is automatically pumped, received, filtered and put aside for rendering. Blood is pumped into a storage tank, from which it is dosed into the rendering tank. Offal solids slurry is made to pass through a screen. Liquid drained from the screen is sent for effluent treatment while the solids are disposed off by composting into manure, rendering into animal feed additive or sale (all solids except feathers) to fish farmers. In some countries head, feet and blood are consumed and they must be handled hygienically for such use. Manual handling of offal in the process house is the surest way to downgrade your product hygiene. Therefore a good layout makes full use of slurry floor gutters, automatic feather-offal pump, blood pump and automatic screening of slurry.

7.10 Portioning and Packing

To obtain high quality de-boned meat it is important to mature the poultry carcasses at 0 to +4ºC for 4-5 hours counting from the moment the bird was killed. After maturation the carcasses are portioned and then deboned. For small plants it is usual to have disc-cutters and cone-de-boners for making the initial cuts and following up with manual de-boning/trimming and packing.

Giblets are sold with the carcasses where they are meant to be sold as full frozen chicken. For trussing whole carcasses a bagging horn is used. An alternative to this is the automatic pneumatically operated bagging machine which can handle 700 birds an hour. After this, the un-bagged birds, meant to be sold as fresh chilled are packed with shell ice in crates. Bagged birds meant to be sold as frozen are sent to the blast freezer.

8 Utilities

8.1 Refrigeration

The refrigeration section serves the following needs:

a) Chilled water for supply to the spin chiller(s) (at + 2ºC) in sufficient quantity (2.5 litres per kilogram of dressed weight)
b) Supplementary ice for the spin chiller (at 0ºC to -12ºC) at 25% of dressed weight
c) Ice for packing fresh chilled product for dispatch (at 0ºC) in quantities sufficient for travel to market
d) Blast freezers and plate freezers, where required (at -40ºC)
e) Frozen store (at -18ºC)
f) Chill store and maturation store (at between 0ºC and +4ºC)

The refrigeration plant also needs to cool working area like packing room, common areas for product dispatch and product movement within the plant (at +12ºC). These requirements **cannot** be served by window air-conditioners.

Therefore the first point to be noted is that the refrigeration section must never be under-sized. The capital outlay for this section is typically much higher than that for processing equipment in small semi-automatic plants. Therefore the tendency of most entrepreneurs is to skimp. This is fatal.

Slaughtered chicken is water-chilled to bring its temperature down from around +38º C to under +6º C by keeping the carcasses for around 25-30 minutes in the spin chiller. To help the chilled water percolate by allowing birds to sink, the water bath has built-in air agitation. Also, heat transfer is aided by using a counter-current chilling method. Fresh chilled water is supplied at as close to freezing temperature as possible. In water chilling some amount of water pickup occurs so that the yield is typically around 102-103% w/w even after the carcasses are allowed to drip to remove excess water.

Cooling below +6ºC is possible only if the cooling water is supplemented with ice, preferably in the form of flakes. If the flakes need to be stored, they must be kept at -10ºC, else they stick together into lumps.

Besides water-chilling, for adequate preservation till they reach the point of consumption, chickens need to be cooled further. This is done by blast freezing the carcasses using blasts of chilled air of around -40ºC till the surface temperature reaches around -35º C (at which time the core temperature is around -10º C). Then the chickens are transferred to the frozen store, where, in less than 24 hours, the temperature equalizes to around minus -18º C. This then gives the product an enormously long shelf life of up to a year.

Air chilling is also useful for further coooling of chickens targeted for sale as fresh chilled. In this case the carcasses are cooled to a temperature just above 0º C. However although it has some advantages, air chilling is more expensive and requires more capital to set up and therefore it is not likely to become popular in Asia for some time. It is standard only in Europe.

Fresh chilled chickens are packed in crates with ice, typically shell or tube ice weighing up to around half as much as the payload. Chickens treated in this manner, provided they are always kept in ice, are capable of lasting for 3-4 days under ideal conditions. Fresh chilled chickens are soft to the touch and do not need to be thawed before cooking. In this respect they appear more acceptable to consumers who are used to freshly slaughtered chicken from the wet market.

Blast frozen chickens are typically not sold immediately after slaughtering. The main benefit of blast freezing is to be able to preserve chickens for long periods of time to smoothen out supply and demand mismatches and to control market slumps arising out of these irregularities. Blast frozen chickens are hard to the touch and to that extent appear "different" to such buyers who are used to the wet market.

Blast freezing must be very rapid after chicken come out of the spin chiller. This can only be achieved by a suitably large refrigeration capacity. The importance of rapid freezing and maintenance of a tight cold chain to product quality and keeping properties cannot be over-emphasized.

When chicken are frozen slowly (as in the case of a low powered freezing chamber or when chilled chicken are placed in a freeze display shelf of a refrigerator), proteins in the meat get denatured and the product never tastes good anymore. Therefore slow freezing or re-freezing is the worst treatment you can give to your product.

The maturation store is necessary if you aim at producing very high quality fresh chilled deboned products. Placing chilled carcasses in the maturation chiller for 4 hours at 0 to +4°C before they are portioned and deboned results in a very soft and tender product.

Refrigeration forms not only a large part of the investment but also accounts for the larger part of the processing cost. Therefore it is useful to consider (a) the relative advantages of alternative technologies and (b) system configuration - whether you should opt for a centralized bank of compressors or a distributed array of compressors. Ask Aptec to help you decide so that your operating cost is minimized. Those seeking detailed information on chilling and freezing chicken must read the article titled Chilling, Chiller Design and How to Choose A Good Machine on the Aptec website.

8.2 Raw Water

To understand the significance of water in your process plant please read the APTEC Report – Water Recycling in Poultry Processing – State-of-the-Art

Raw water is treated by filtration and chlorination or other means depending on initial quality, to reduce bacterial count and is pumped into an overhead tank. From here the water flows down to the water chilling plant, the slaughter plant, wash areas and all domestic water lines. The tank must be at least 10 metres above the ground to create sufficient pressure. Because water requirement in the plant is intermittent, it is useful to have a large diameter main header running through the length of the plant, from which the supply lines are taken to different consumption points. This ensures decoupling of pressure variations owing to discharge at different demand centres

Generally the rendering block is designed to hold the overhead water tank. At 3 floors it already has the requisite height - the water tank gives it an additional 1/2 floor height.

8.3 Hot Water

Hot water or steam is required for heating the scalder. In installations where rendering plants are installed or proposed, it pays to plan from the beginning for steam heating. Then the rendering cooker and scalder can share the steam from the same boiler. Steam is generated typically in an agro waste or oil fired steam boiler which supplies it to demand at 10.54 Kg/cm^2. This high pressure steam is required in the rendering plant. For the scalder, the steam is supplied at a lower pressure of 2 bar through a pressure reducing valve.

Many chicken processors have benefited by using agro-waste for making steam. Look around carefully in your area for such agro-wastes. Typical wastes are coconut shell, coconut leaf stem, paddy husk, saw mill off-cuts or even fresh or spent litter. Aptec will help you design a low operating cost steam raising facility.

8.4 Compressed Air

An air compressor with a storage tank is required. The compressed air is at 8 bars pressure and needs to be dried by a refrigeration type drier. Silica gel systems are not effective for chicken processing plants in tropical climates.

8.5 Vacuum

Vacuum is required for suction of lungs from carcasses using lung-sucking pistols and for transport of blood from the bleeding tunnel or trough to the rendering plant or disposal. For this a water-ring vacuum pump capable of generating 100 mm of water column and two vacuum holding tanks as well as the requisite piping with swept bends are required. Model DV-50 water ring vacuum pump from Kirloskar is the ideal and only Indian pump matching these specifications.

8.6 Power

Power requirement for such a 2000 BPH plant is of the order of 900 kVA, but the actual depends very much on the refrigeration load. Load of the slaughtering section is minimal.

Table 7 Electrical Load	
Slaughtering section	77 kW
Rendering	65 kW
Refrigeration	390 kW
Other	158 kW
TOTAL	**690 kW**

It is easy to make inadequate provision for power in a chicken slaughtering plant. To give you an idea, tabulated below is the connected load data for different sections of a 1300 birds per hour plant designed to operate around 10 hours per day. Of these, the rendering plant, effluent treatment plant and cold store and ice bank tank are designed for 24 hour operation. Design the backup power supply to ensure economy. When you use AptecApp, for any production setting you choose, it will calculate the approximate power requirement.

8.7 Effluent Treatment

Wastewater from the plant goes into a buffer tank via a fat trap. The buffer tank is sized to hold the wastewater generated during the operating hours and feed it over 24 hours into the treatment facility. After treatment to meet environmentally acceptable quality standards, the water is discharged as fit for irrigation purposes. Wastewater streams as discharged from the plant are composed as follows:

Table 8 The wastewater characteristics are typically:		
	Slaughter	**Rendering (20-40 Kl/day)**
COD	3500/4500 ppm	5000/6000 ppm
BOD	2300/3000 ppm	3000 ppm
Suspended solids	1500/2000 ppm	500 ppm
Oils and fats	1500/1800 ppm	---
Kjeldahl nitrogen	200/250 ppm	500/600 ppm
H_2S	----	300 ppm
NH_3	----	350 ppm

8.8 Washing and Disinfection

Equipment washing is performed after each production shift. High pressure wash with plain water at 30-40 bar is used for removal of dirt. Foaming with an alkaline foaming detergent is then performed for a usual contact duration of 20 minutes or as specified by the manufacturer of the detergent. This is followed by a high pressure rinsing to remove the detergent and residual dirt which should be loosened now. The last step is washing with a disinfectant and then rinsing to remove the disinfecting agent. Mere disinfection[6] is not a substitute for washing. If the machine is dirty, that dirt will continue to harbour microbes even after overdoses of disinfectant.

Depending on hardness of local water, a periodical acid cleaning is recommended. This can be once every two-three weeks. It removes deposits of calcium and magnesium salts and iron oxide. If this is done using a quaternary ammonium salt (quat), it is necessary to use a chlorine type disinfectant once every week, to prevent bacteria developing resistance.

8.9 Ventilation

Ventilation in the process plant needs careful design – it cannot be left to nature. Aptec posted a chapter on the subject on this website as part of its October 2022 issue of the Industry report. The contents of this write-up will form the chapter on the subject in the free-to-download "Handbook of Poultry Slaughterhouse Design" which is under preparation. Similarly, another chapter of the book titled "Chilling, Chiller Design and How to Choose a Good Machine" has been on the website for some time past already. In the meantime we are mentioning the salient points here

8.9.1 Processing steps preceding the final processing area comprising cut-up, portioning, deboning and packing generate enormous quantities of aerosol contaminants which drift all over the plant under natural flow of air. In the spin chilling stage large quantities of water vapour join this unwanted air movement. Together these cause microbial contamination to the finished product as well as vitiating the working environment of the final processing area. In addition such ingress of water vapour also raises your refrigeration power bill.

8.9.2 Since products in the final processing area do not undergo a subsequent wash, contaminants accompany the packed product and reduce its shelf-life.

8.9.3 Engineering a system to ensure a purpose-built air movement regime can solve this problem. But it is difficult to retro-fit such an air movement regime. So it must be designed from the very beginning.

To learn more about contamination, odour and ventilation, read also the following articles on the Aptec website. APTEC_Article_on_Reducing_Slaughterhouse_Wastestream_Odour

9 Manpower

Estimate of total manpower requirement is calculated for each project setting in AptecApp. It can be seen to change depending on hours of operation and amount of portioning/deboning to be done. Because the product mix needs to change according to market requirements it is not possible to give any one manpower figure for a plant size unless all these factors are known.

Bird catching at the farm sheds is done under dim light and birds are transported in the cool hours of the day to save them from heat stress. A standard truck transporting birds in cages moves approximately 1400 birds every trip. Men, as opposed to women, are better suited for bird catching and transport.

1. In plants where the transport conveyor for live chicken crates does not exist, two persons are available in the off-shift in the slaughtering section. They alternately unload bird crates from trucks and clean the plant using high pressure hoses.

2. In plants where a transport conveyor for live chicken crates does not exist, at the start of the main shift, one man takes up the crates (containing from 8 to 12 birds each) and positions them conveniently for the bird hanger. For the rest of the time he attends to the crate washer.

3. One man is suitable for hanging the birds at 1000 BPH if the roller conveyor brings the crates just below the hanging section of the track. In these plants the conveyor moves in the opposite direction of the track.

4. One man (1000 BPH) performs manual killing either by halal or other manual methods.

5. One man is stationed in the scalding hall to attend to plucker and scalder. He also picks pin feathers in case required.

6. One man cuts the vent using the vent drill, achieving 1000 BPH

7. For every drill employed, one man enlarges the vent cut with a knife

8. For every knife cut, one man scoops out the pack using the evisceration fork

9. At 1000 BPH one woman removes the gall bladder

10. For every 1000 BPH one woman each cuts out the gizzard, liver and heart from the pack and drops the remaining pack into the trough and the edible offal into the giblet flumes

11. For every 1000 BPH two men cut the gizzard open and wash the insides and one operates the gizzard control table to peel gizzards. Alternatively, if you use automation only one attendant is required for the section.

12. For every 1000 BPH one woman slits the neck skin and one man cuts off the neck using pneumatic neck shears (if the market requires necks removed). Alternatively, at a line speed of 1000 BPH or so, he manually removes the trachea and crop. The manner in which Halal is performed can cause the trachea to remain in the carcass even after the bird passes the head puller.

13. Every 1000 BPH requires one man with lung sucker to remove the lungs

14. One man to cut the hocks and drop the carcasses into the screw chiller at approximately 500 BPH, in case this is done manually. Else when a hock cutter is used, human intervention is not required.

15. One man to remove cut hocks from the shackles at approximately 500 BPH in case this is done manually. Else when a hock unloader is used, human intervention is not required.

16. Six persons in the dripping and packing department for 1000 BPH. More in case weighing is performed manually. In that case the number depends on design of the weighing, batching and packing requirements etc as per your choice.

17. The number of persons required for portioning and deboning depends on your throughput and production programme. The App shows the change as you change the product mix.

18. One supervisor (who also acts as replacement for absent workers).

19. One electrical and one mechanical maintenance man

20. Two or more men to handle refrigeration, blast freezing and transport of ice within the plant, depending on capacity, freezing requirements and plant layout.

10 Portioning, De-boning and Product Mix

The product mix in AptecApp is derived from the percentage yield of different parts of a chicken upon portioning and deboning. Some of the un-conforming parts that these processing steps yield need to be packaged as parts of the next product type. For instance, portioning delivers upper and lower back cuts which cannot be packaged and sold as portions and must be bundled as curry-cuts. Similarly whole wings are separated, to be sold as portions when you attempt to produce boneless products, because it is very difficult to debone wings in their entirety.

The case for upper and lower backs being bundled as curry-cuts requires further attention. If you sell all your whole carcasses as such, and also attempt to sell your curry-cuts as consisting entirely of upper and lower backs (and necks, skin-on), the contents may not be appealing to the buyer. Therefore, you will need to add some actual curry-cut (meaning cutting through the bones of torsos of a chicken into curry type pieces) and mix the pieces with the upper and lower backs to make attractive curry-cut packs.

To further help you realize the product mix better, Aptec has included data pertaining to yields in the App and here as well. With the second graphic we have tried to reconcile our data with those from Meyn graphic, which you can obtain from them by reaching Mukanjay Singh +91 88603 29800 at Meyn India.

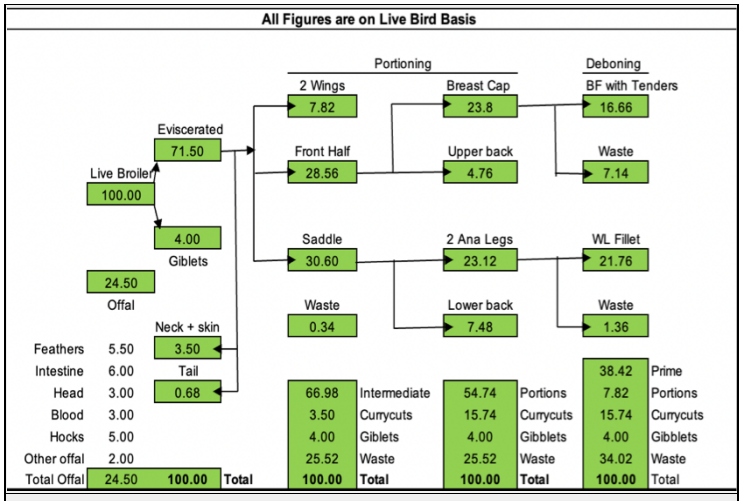

Figure 9 Weight percentages of different parts of a chicken (skin-on). Source: Meyn Food Processing Technology, The Netherlands

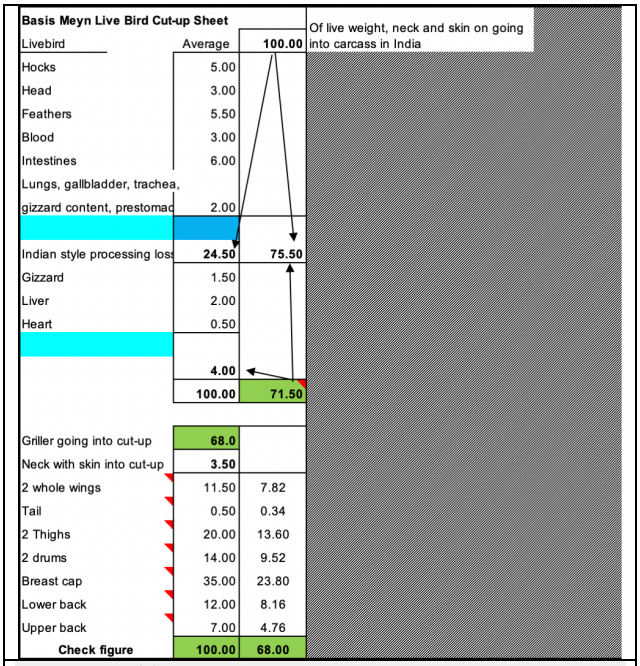

Figure 10 The European griller versus the Indian whole dressed chicken. We needed to create this set of data because the Meyn graphic incorporates one rounding off which results in errors in AptecApp.

Do remember that the above represents only the average yields. In reality yields will differ according to breed, gender, nutrition, general health and age of the bird and even the stress encountered during transport to the plant and up to the point when they are slaughtered.

11 Design Considerations

11.1 Standards

Standards to be used when designing a plant are typically the Codex Alimentarius, The EU Standards, USDA Standards and others. To be able to conform to these standards great care must be exercised at the design stage itself for all civil and construction aspects and of course in selection of machinery. All the advice given in this document is in keeping with these standards.

11.2 Design Thumb-rules

Some broad guidelines for design of the building and general layout are given below.

The entire plant building can be built using a 6 metre grid of columns with beams below the ceiling (if you are using option given in para 5.1 for construction. The floor should have a slope of 0.5% (it is not comfortable for people to stand for long hours on slopes in excess of 1%) leading into floor gutters which will require to be built in all the slaughter rooms and all non-frozen refrigerated areas. Finished floor surface is best achieved with a high density, light coloured, acid-proof stone or vitreous tiles having a high degree of wet traction. Look around for a suitable rock in your own area. In India all these qualities are met very economically by Kota stone. It is a high silica content limestone - the silica having once been riverine silt.

If you have plans for using chicken slaughtering machinery of global standards in the building, then the clear height in the slaughtering plant area from finished floor level to bottom of beams (or false ceiling if made of PU sandwich panels) should be 4.4 metres or more.

Except where you use insulated pre-formed panels, the walls have to be glazed up to around 2.5 metres and have plastic emulsion paint above the glazing. Use of epoxy in place of glazed wall tiles (and also as lining to floor) has been tried in India with very disappointing results. Avoid the use of paper lining, cloth, wood and asbestos in construction of slaughter and cold areas.

Construction standards discourage the use of underground gutters in the slaughter and refrigeration areas. All gutters need to be open with steel grid covers in sections of 1 metre or some such convenient lengths. These are removable, for easy cleaning. All gutters are either of 300 mm width or 600 mm width and slope at 0.5% or more towards the offal pit. Gutter bottoms are best made with a semi-circular profile - flat bottomed gutters are ineffective. Slot drains may also be used, particularly in the cut-up, deboning and packing areas

Some “experts” advise lining of floor gutters with stainless steel. This is a terrible idea, serves no useful purpose, and in fact leads to uncontrollable bad smell in the plant. Stainless steel lining tends to delineate from the mortar matrix over time and form an un-reachable space for spread of putrification, smell and eventual product contamination. In any case, product falling on to the processing plant floor or onto or into floor gutters is required by standards to be rejected. So what earthly purpose can stainless steel lining inside floor gutters serve? Remember the rule – stainless steel and non-contaminating plastic is required only for surfaces that come into regular contact with the product - not for surfaces that do not come into contact.

Gutter covers may be painted or if possible, dip-galvanized after fabrication.

Wash basins/stands are located just inside the slaughter area at all doors with foot-dips at the doors. The wash stand should have elbow or knee operated taps. Bathrooms should not open directly into process areas.

For the refrigeration section it is important to have the same finished floor level as the slaughter area. This will prevent accidents. Refrigeration area floors where the temperature goes below freezing, should never have tiled or stone cobble floors. The best flooring is dewatered granolithic for such areas.

If refrigeration areas are to be built on a greenfield plot, consider an approximate height build-up of 600 mm comprising floor insulation, transverse anti-frost-heave[xix] tubes or floor heaters, and suitable flooring. Ignoring the use of breathing tubes/floor heaters results in frost-heave and cracked floors, leading eventually to poor hygiene.

For planning frozen storage area consider 650 Kg of chicken per sq metre. Consider 0.5 kg of ice per kg of chicken for shipment of fresh chilled product.

12 Future Growth and Diversification

The key to future growth and diversification is modularity of machinery.

a) Ascertain if the machine-ends can be unbolted and expanded by the simple expedient of adding more sections. This is typical of well designed conveyors, troughs, scalders, spin chillers, cone de-boners, and overhead main conveyors.

b) Ascertain also if the overhead conveyor can be dis-assembled and re-configured into a changed layout without having to discard elements and without too much reworking.

c) Ascertain from the layout submitted to you if extensive changes in the building would be necessitated in the event you want to expand. If extensive changes will be required, that layout is bad.

d) Ascertain whether the layout allows you to conveniently place advanced machinery like automatic evisceration machines or automatic weighing and grading machines without shutdowns or dismantling of walls, doors, lintels etc.

e) These attributes are essential if you wish your business to grow. When you need to change the processing details or expand, you cannot take long shut-downs for modifying machinery or building. If you take long shut-downs, you may lose your markey.

A slaughter house is the first stepping-stone to further processing of chicken.

Initially the slaughterer sets up facility for portioning of chicken, and deboning of prime portions using manual methods. Next, as these volumes increase, the slaughterer may wish to go into RTC (ready-to-cook) products like deboned meat, curry-cut, etc. Finally he may offer RTE (ready-to-eat) products such as formed products (cutlets, kebabs, nuggets, burgers, momos), stuffed products (salamis, sausages) or cuts (grilled chicken, wing tips, drummets) specifically fried/smoked/steamed.

However, designating the same premises for processing and further processing for ready-to-eat products is not acceptable – they should be in different or adjacent premises so that cross contamination does not occur..

13 Link to Video on YouTube

Just over a decade ago, on Aptec's advice Meyn sent an expert team to shoot a video at three processing plants it had designed and built in Tamil Nadu. These were Suguna, Shanthi and VKS (later known as SKM). These plants were then operating at 4000, 3000 and 2000 BPH respectively. The video is available for viewing and downloading on YouTube as **"From Plan to Plant"** and has been watched by over a million viewers. Most of the description and details given in this document can be observed in that video. Both the Meyn and Aptec websites carry links to it.

14 Sourcing Design, Funding, Equipment and Supplies for Poultry Processing

Table 11 Aptec Vendor Database for Poultry Processing	Rev 4, Date 25 Sep, 2023
Articles, Scientific, Technical	Scientific Articles, repository of [1]
Audit and Consultancy	Biosecurity Audit for Certification [3.1], Hygiene Audit [3.2], Time and Motion Performance Audit [3.3], Layout and Work-flow Audit/Design [3.4], Poultry Processing Project Engineering Consultancy [3.5], RTE Formulations [3.6], RTE Test Kitchen [3.7], Farming and livestock [3.8]
Biosecurity	See Hygiene, …….
Boilers	Steam Boilers [5.1], Hot Water Boilers [5.2],
Building Design & Construction, Projects	Civil Construction [6.1], Architecture [6.2], Turnkey Engineering[6.3], Turnkey Plant Design and Supply[6.4], Consultants For Arranging External Financing of Projects [6.91]
Clean-in-place, Steam-in-place	See Hygiene, Housekeeping….
Compressed Air,	Air Compressors [7.1], Compressed Air Dryers [7.2], Purge Valves [7.3]
Controls	Control Panels [9.1], Processing Plant Compatible Drives, Motors [9.2], Temperature Controller [9.3], VLT [9.4],
Consumables	[7]

Conveyors	Belt Conveyors [11.1], Modular Conveyors [11.2], Roller Conveyors [11.3],
Coops, Crates	Coops or Crates for Live Poultry [13.1], Product Crates [13.2], Fresh Product Crates [13.3]
Design, Plant Layout	See Audit, Building Design …
Doors	Docks for truck loading bay [15.1], Dock Leveller [15.2], Dock Shelter [15.3], Hatch Door [15.4], Polymer Sheet Doors [15.6], Refrigeration Doors [15.7], Sliding Door [15.8], Wicket Door [15.9], Rolling Shutter [15.10], Emergency Door [15.11], Fire Resistant Door [15.12]
Directory	[17.1]
Financing of Project	See Building Design….
Flooring	Acid-Proof Flooring [19.1], Anti-Slip Flooring [19.2], Kota Stone Flooring [19.3], Polymer Flooring [19.4],
Face Shields	See Hygiene….
Fire Safety Equipment	Fire Resistant Doors [21.1]
Hygiene, Housekeeping, Biosecurity, Safety, Supplies	Air Curtains [23.1], Air Showers [23.2], Air Tunnels [23.3], Bio-hazard Bins [23.4], Brooms [23.5], Clean in Place [23.6], Dustpans [23.7], Entrance Solutions [23.8], Floor Washing & Mopping [23.9], Foam Washing Systems [23.10], Gun Lance for Plant Washing [23.11], Hepa Filters [23.12], High Pressure Washers [23.13], Hygiene Station [23.14], Industrial Vacuum Cleaner [23.15], Laundry, Washing Supplies [23.16], Plant Washing System [23.17], PP Gear [23.18], Rodent Control [23.19], Steam in Place [23.20], Strip Curtains [23.21], Vacuum Cleaner, Industrial [23.22], Washroom Accessories [23.23], Waste-bins [23.24],
Lamp, Electric/Luminaire	Incandescent [25.1], Fluorescent [25.2], LED [25.3], HP Sodium Vapour [25.4],
Laundry Equipment, Industrial	Washing Machines [27.1], Ironing Equipment [27.2]
Meat Processing Machinery	Large Animal Slaughter, Red Meat Plants [28.1],
Packing Machines and Supplies	Adhesive Packing Tape [29.1], Batch and date code printing [29.2], Bar-coding, QR Code [29.3], Branding, Date & Product Information Printing Equipment [29.3], Cloth Tape [29.4], Coding Solutions [29.5], Impulse Heat Sealer [29.6], Duct Tape [29.7], Labels [29.8], Low Temp Stable Sealing Tape [29.9], Manual Tape Dispenser [29.10], Masking Tape [29.11], Pack Labelling, Pack Printing Machines & Materials [29.12], Packing Machines [29.13], Tape Sealer [29.14], Traceability Systems [29.15], Wicket Bag Sealing Tape [29.16], Shrink Tunnel [29.17]
Personal Safety	See Hygiene…..
Pest Control	See Hygiene…..
Poultry Processing Plant, Machinery	Automatic Poultry Processing Equipment [31.1], Manual Poultry Processing Equipment [31.2], Table [31.3], Trolley [31.4], Metal Detector [31.5], Reconditioned Poultry Processing Machinery From Europe [31.10]
Poultry and Meat Further Processing Plant, Machinery	Further Processing Equipment for meat [33.1], Kitchen and Scullery Equipment [33.2]
Processing Tools, Components, Supplies	Apparel [See Hygiene….], Blood Pump [35.1], Butchers Steel [35.2], Cleaning Chemicals [35.3], Circular Knife [35.4], Feather Pump [35.5], Hock, Giblet Pump [35.6], Knife Grinder [35.13], Portioning/filleting Knife [35.7], Plucker Fingers [35.8], Pump [35.9], Semi-automatic Hand Tools [35.10], Slurry Pump [35.11], Crate Washer [35.12], Circular knives [35.13]
Refrigeration Systems	Ammonia Systems [37.1], Cryogenic Freezer [37.2], Evaporator [37.3], HCF System [37.4], Ice maker [37.5], Ice Packs and Dry Ice [37.6], Plate Heat Exchanger [37.7], Sandwich Panel [37.8], Tunnel Freezer [37.9], Refrigeration Turnkey [37.10], Spiral Freezer [37.11], Acoustic Insulation Panel [37.12], Rock-wool Panels [37.13], Cryogenic Gas [37.14]
Rendering Plant, Rendered Meal	Rendered Meal Bulk Buyer [41.1], Rendering Plant [41.2], Batch Cooker [41.3], Continuous high temperature cooker [41.4] Raw Material Preparation and Sizing [41.5],Conveyors for rendering [41.6], Raw material preparation and storage [41.7], Rendered Meal Milling[41.8], Filter Press [41.9], Heat Recovery [41.10], Odour Control [41.11]
Rodent Control	See Hygiene
SS Custom Fabrication	[43.1]
Temp Measurement, Control & Logging	Electronic Digital Hand-held Thermometer [45.1], Glass Thermometer [45.2], Process Temperature Controllers [45.3], Temperature Dial Gauge [45.4],Temperature Logger [45.5],
Vacuum Systems	Vacuum Pumps [45.6], Vacuum Conveying Equipment [45.7]
Ventilation	Air Curtain [47.1], Exhaust Fan [47.2], Roof Extractor [47.3],
Waste Handling , Treatment	Raw Water Treatment [49.1], Solid Waste Management [49.2], Wastewater Treatment [49.3], Ozonation [49.4]
Weighing Systems	Bench Scale [51.1], Check Weighing Machines and Systems [51.2], Floor Scale [51.3], Multi-head Weighing Packing[51.4], Platform Scale [51.5], Pan Scale [51.6], Weighbridge [51.7], Weighing Machines [51.8]

1	**Airtècnics,** C/ Conca de Barberà, 6**,** Pol. la Bruguera**,** 08211 - Castellar de Vallès**,** Barcelona Spain https://www.airtecnics.com, +34 937 15 99 88 [47.1],
2	**Alfa Food & Poultry Projects BV**, Impuls 23, 1446 WC Purmerend, The Netherlands, tel +31 299 748 171, fax +31 299 460 776. Agent in India - NH ProPOWER Consultancy Services, [31.1], [31.10], [33.1]
3	**Aman Enterprises** B9/147 Sector 4, Rohini, New Delhi-110085, +91 11-27062171, (M) +91 9350525443, +91 9958048947, +91 9310125442, amandevki@gmail.com, info24amanenterprises@gmail.com, www.amanenterprise.co [37.1], [37.4], [37.10],

4	**Ammeraal Beltech India**. Unipunch Pride, 3rd Floor - G1. Door No. 40, 2nd Main Road, Ambattur Industrial Estate, Chennai, 600058, India. +91 44 2653 4244, www.ammeraalbeltech.com, +91 99405 97646, +91 99403 08049, Jebbel Paul. [11.1], [11.2], [11.3],
5	**Altomech Pvt Ltd,** 3/519, SF.NO:108/4, Manickapalayam Road, Manickapalayam, S. S. Kulam (via), Kunnathur Pudur Post, Coimbatore, Tamil Nadu, India-641107. +91 95851 33033, info@altomech.com , altomech@gmail.com, www.altomech.com, [45.7], [23.22],
6	**Aptec** (Alok's Poultry Technology Pvt Ltd), 282, Power Officers' Society, Plot 14-15, Pocket 2, Omega 1, Greater Noida 201310 India. alok@aptec.in, rajalok@gmail.com +91 9811049914 [3.3], [3.4], [3.5], [6.3]
7	**Aren Rendering Solutions** (Aren Farms Pvt. Ltd), Plot no 551, Sri Sai Balaji Township, Shadnagar, Rangareddy dist, Hyderabad-509216. Narendhar Reddy Varla, nrvarla@arenfarms.com, +91 96666 60574 www.arenfarms.com & www.aren.com.in, [41.2]
8	**A & S Thai Works Co Ltd,** 99/199 Moo 1 Theparak Road, km 22 Bangsaothong, Samut Prakan 10570 Thailand. +66 2313 1540, Fax: +66 2313 1550, sales@asthaiworks.com, www.asthaiworks.com, [41.2],
9	**Atco Sensors Ltd**, Katrak Road, 6 A Lalwani Industrial Estate 14 G D Ambedkar Road, Wadala. City, Mumbai. State, Maharashtra 400031, India, www.atco-industries.com, [51.7],
10	**Avery India Ltd**, Plot Nos. 50-59, Sector 25, Ballabgarh, Haryana 121004, India. +91 129 409 4400 +91 129 409 4500 www.averyweigh-tronix.com, [51.7], [51.5], [51.8], [51.1],
11	**Baader Food Systems** Denmark A/S, Vestermøllevej 9M 8380 Trige Denmark; BAADER Asia Pte. Ltd., 71 Ubi Crescent #01-03 Singapore 408571, Yee Teck Ng, YeeTeck.Ng@baader.com>, Nikhil DuBois <nikhil@rndautomation.co.in>, [31.1]
12	**Bala Industries and Entertainment Pvt Ltd** (Formerly V. J. Equipment Pvt Ltd) Gat No.88, Village Jambhul, Tal Maval, Pune 412106, Maharashtra, India. www.balaindustriesincubator.com/, [13.1], [23.11], [23.19], [23.22], [23.9],
13	**Bayle (India),** 17/1 Tatya Tope Society Phase 1, Opp Shivarkar Garden, Wanowrie, Pune, India +91 95525 65264, shekhardcruz@gmail.com, Rajshekhar D'Cruz, [31.1], [31.2],
14	**Blue Star Limited**, Kasturi Buildings, Mohan T Advani Chowk, Jamshedji Tata Road, Mumbai - 400 020, India. +91 22 6665 4000, 1800 209 1177, Fax: +91 22 6665 4151, [37.4], [37.8],
15	**Bright Industries**, 286/1 NKT Nagar, Vivekanandhar Street,, Nanjegouden Pudur, G N Mills Post,, Coimbatore 641029. +91 93632 28481, +91 98947 88786, bright_ind@hotmail.com. Abdul Nazar, [11.3], [43.1],
16	**BSA India Food Ingredients Pvt. Ltd,** Tower C 806 Unitech Business Zone, Nirvana Country, Sector 50 Gurgaon NCR, India. Amod V. Apte, +91 86969 24195, +91 124-4049807, www.bsaindia.in [3.6], [3.7],
17	**Camb Machine Knives** International LLC, 911 Brenda St., Houston, Texas 77076-3440, USA, Tel: 713-884-8855, Fax: **713-884-8855, Sales@cambknives.com** [35.13]
18	**Carfed S.A.** 10 – Zona Industriale, San Giuliano Milanese, Lombardy, 20098, Italy. info@carfed.it Manufacturers of poultry crates, http://www.carfed.it/poultrytransportation, [13.1],
19	**Control Print (India) Limited**, Sector 4, Noida, Gautam Budh Nagar, Uttar Pradesh, India. +91 22285 99065, +91 22669 38900, sales@controlprint.com, [29.2], [29.3], [29.5],
20	**Danfoss Industries Pvt. Ltd**, Unit No. 602, 6th Floor, RMZ Millenia Business Park II, 4B Campus, No. 143, Dr. MGR Road, Perungudi 600096 Chennai, India. danfoss.india@danfoss.com, www.danfoss.com, [9.4],
21	**Deccan Automation Technology**, Gat No. 1074/1, Alandi Markal Road, Solu Khind, Near Rich Crop Science, Markal, Pune- 412105, Sukhadev Darekar, +91 74477 81112, deccanautomationtech@gmail.com, www.deccanautomation.in, [31.1], [31.2],
22	**De-Ion Systems,** C-281/1, 7th Cross, 1st Stage, Peenya Industrial Estate, Bangalore 560058 India. S. Jagadish Bhat, +91 98454 48835, +91 80-28392127, jagadishbhat2002@yahoo.com, info@deion.co.in, [49.1], [49.3],
23	**Dhopeshwar Engineering Co,** A-16 Cooperative Industrial Estate, Batanagar, Hyderabad 500 037. dhopeshwar@gmail.com. Shirish Dhopeshwarkar [31.1], [31.2],
24	**Dhumal Industries**, E – 36, D Road, MIDC, Satpur, Nashik – 422007, MH, India. +91 982 208 4683, +91 25 3257 6084, sales@dhumal.com, www.dhumal.com, [13.1], [13.2], [23.18],
25	**Directory of Vendors for Food Processing Industries Worldwide,** www.hyfoma.com/en/companies, [17.1],
26	**Diversey Global Headquarters**, 1300 Altura Road, Suite 125, Fort Mill South Carolina, 29708, (803) 746-2200, (800) 668-7171, (800) 558-2332, (800) 842-2341, [23.10], [23.16],
27	**Domino Printech India LLP**, Plot No. 167, HSIIDC Udyog Vihar, Phase 1 Gurugram, Haryana 122016 India +919599488058, enquiry@dominoindia.com, [29.12], [29.3], [29.12],
28	**Dr Froeb (India) Pvt Ltd**, C-20 Sector 2, Noida 201301, India. +91 98110 89930, Athul Jain, atul@drfroebindia.com [33.1], [33.2]
29	**Duram Rubber,** Amnon Ben Peretz, +972 9-7474458, +972 9-7474479 , duram@ntvision.net.il, [35.8],
30	**Dutch Poultry Tech**. Henry Regeling, +31.622.794.567, henry@dutch-poultry-tech.com www.Dutch-Poultry-Tech.com, [31.10]
31	**Ecorole,** Sr No 59/1m Sai Industrial Estate, behing Maharashtra Warehouse Godown, Chovisawadi, Pune, Maharashtra 412105, India, +91 99235 92660, +91 80871 22972, shrutika@ecorole.in, arun@ecorole.in, info@ecorole.in, www.ecorole.in
32	**E- Pack Polymers Private Limited** 61 – B & C, Udyog Vihar, Surajpur, Kasna Road, Greater Noida.(U.P.) India. Pin 201306 +91-8130444477, sales@epack.in , [37.8],
33	**Elgi Compressors,** Toll-free (India) 1800-425-3544, , 1800-203-3544, enquiry@elgi.com, , www.elgi.com, [7.1],
34	**Envair Electrodyne Ltd** (formerly Kirloskar Electrodyne) 117, S-Block, MIDC, Bhosari, Pune 411026, Maharashtra, India. **www.kirloskars.com**, [23.12],
35	**Enviro Care India Private Limited**, #43, 2nd Street, AA Rd, Madurai, Tamil Nadu 625016, India. +91 98211 78781 www.envirocareindia.com, [49.1], [49.3],

36	**Eureka Doors,** 203, Vikram Goldmine, Opposite Venus Traders, Behind Hotel Rupali, FC Road, Pune 411 004. Maharashtra, India. +91 8888 78 4444, +91 9373040830, sales@eurekaindia.com, info@eurekaindia.com , [15.6],
37	**Eureka Forbes** https://www.forbesprocleaningsolutions.com, [23.22], [49.1],
38	**Euronics Industries Pvt Ltd**, 567-566, Udyog Vihar, Phase - 5, Gurugram 122016, www.euronics.co.in, [23.8], [23.14], [23.18], [23.23],
39	**Evoqua Water Technologies India Private Limited**, DLF IT SEZ Park, Block 8, 5th Floor,, No: 1/124 Mount Poonamallee Road, Manapakkam, Chennai 600089 India.+91 44 6136 3100, sales.in@evoqua.com, [49.1, [49.3],
40	**Ezytek Clean**, G-137,Sector-63, Noida, www.ezytekclean.com, [23.22], [23.20],
41	**Finale Machinefabrieks,** A11/1/13, MIDC Area, Ahmednagar 414 111, India. +91 9423006250, +91 9422226250 Telefax +91 241 2422343, finale_engineering@yahoo.com, [41.2], [43.1],
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44	**Godrej Cartini Stainless Steel Knives.** https://www.flipkart.com/kitchen-cookware-serveware/knives-choppers-cutters/kitchen-knives/godrej-cartini~brand. [35.7]
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55	**Intralox India Pvt Ltd**, No 18/23, Peenya 1st Stage, Phase -1, Peenya, Bengaluru, Karnataka 560058, India. +91 90084 88116, Kartikeyan K, Kartikeyan.K@Intralox.com, www.intralox.com, [11.1], [11.2],
56	**Industrial Refrigeration Pvt. Ltd,** 901, Maker Chambers V, Nariman Point, Mumbai - 400 021, India, +91 22-489-31805 Contact for systems with Grasso compressors. They also represent Geneglace range of FrigoFrance S.A. [37.1], 37.10], [37.4], [37.5],
57	**Ishida India Pvt Ltd** 382, Ground Floor, Udyog Vihar II, Gurgaon 122016, India. 0124 484 4391. Jiro Hatakeyama, MD. +91 97177 91451. [29.13], [29.2], [29.3], [29.5], [51.2], [51.4],
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63	**Khosla Compressors Ltd,** 1, Desh Bandhu Gupta Road, New Delhi, 110055 India. +91 9810700331, info@kgkhosla.com, [7.1],
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78	**Naren Rendering Solutions – See** Aren Farms Pvt Ltd
79	**NeuWave Capital,** Bangalore, India**.** Shriram Karthik, shriram@neuwave.in, +91 91007 98848, ⌈6.91]
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101	**Star Metal Forms Pvt. Ltd**., 162, G.I.D.C. Estate, Opp. Pandesara Post Office, Pandesara, Surat, Gujarat - 394221, India. +91- 261- 2891875, sales@diamondflushdoors.com, [15.1], [15.2], [15.3], [15.11], [15.7], [15.12],
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103	**Storm Engineering India P Ltd**, 220, Ganesh Nagar, At Post: Kesnand, Tal Haveli, Dist Pune 412207, +91-+91 73500 36801, +91 88888 99128, salesstormindia@gmail.com, Prakash Sansare [23.8], [23.23], [23.4], [31.1], [31.2], [31.3], [31.4], [31.10]
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Endnotes

[i] There is no process machinery available anywhere in the world for eviscerating birds after removing the skin. One important reason is that when death occurs, involuntary muscles like those around the cloaca relax, discharging volumes of faeces all around. If the skin is removed at this stage, the entire bacterial load spreads to the meat from where it is virtually impossible to dislodge. It pays to remember that skin is a protective layer, and even in death it continues to protect the meat.

[ii] Ice-pack coolers for this industry are recyclable sealed plastic containers with a mixture of water and propylene glycol. These are pre-frozen in a freezer and then put along with chicken in door delivery vans/pushcarts. Because of the large thermal mass of glycol, these ensure low temperature (typically well below -5°C) of the product for a long time. Naturally, a reasonable thermal mass ratio between that of ice pack and product needs to be maintained to achieve success.

[iii] According to ASHRAE or its sister organization in India – ISHRAE

[iv] Refer Endnotes of March 2021 Industry Report.

[v] The existing Indian rules for discharge of treated wastewater are very stringent (even absurd in the context of contemporary international rules). You are not allowed to discharge this water into natural water-courses, nor into rivers, streams or ponds. You may use it for irrigation in your own land or against an affidavit give it to local farmers for so doing. In other words your project must possess enough land of your own or ensure enough crop land of your neighbours are available for discharge for irrigation. How you may continue to apportion irrigation water during heavy monsoon downpours is ignored – implying thereby that in such events your plant must shut down!

To sum up, an executive wing of the Indian government has, upon displaying chronic, persistent and abysmal executive failure, forsaken its assigned role and turned totally legislative!

[vi] A detailed account of water requirement in processing, including its conservation over the years is given in the article APTEC Report Water Recycling in Poultry Processing State of the Art, which may be downloaded from the Aptec website. Also, when you use the AptecApp for planning your processing plant, it calculates and displays the water requirement as part of its design highlights

[vii] The referenced article makes a case for splitting the processing activity into two – the capital intensive, water intensive and pollution generating killing, evisceration and chilling steps to be performed in a few up-country locations and subsequent portioning packing and marketing (which require less power, use practically no water and generate no pollution), to be performed in multiple urban industrial sheds.

[viii] Refer to the article on evolution of rendering plant design on the Aptec website. General plan and elevation for such a building is given there. The article traces the evolution of rendering design and points out how some perfectly reputable European vendors continue to peddle antiquated layout designs out of sheer mental lethargy.

[ix] This topic is adequately covered in the article on "Evolution of Rendering Plant Design" to be uploaded by March 2023 end on the Aptec website.

[x] A Risk Analysis of Sandwich Panels, http://www.sandwichbau.de

[xi] Wikipedia 2021 Georgia poultry plant accident; Richard Fausset and Miriam Jordan, A Georgia Chicken Town Reels After a Plant Disaster, The New York Times, Jan. 29, 2021; Food Plant Fire Kills 25; Exits Blocked : Disaster: Chicken workers in North Carolina are trapped in a facility that had never been inspected for safety. Another 40 workers hurt, LAT Archieves from Associated Press, Sep 4, 1991; FP Staff (/author/fp-staff) Kanpur: Ammonia gas leak causes explosion in cold storage; five killed, several still trapped, http://hindi.firstpost.com, 15 Mar, 2017; Beth Dalbey, Anhydrous Ammonia Leak Forces Evacuation, https://patch.com/michigan/farmington-mi/, June 14, 2015; Jethro Mullen, Fire at Chinese food packaging plant kills 18, November 17, 2014- CNN.com;

[xii] Pursuant to an investigation of the Jilin Baoyuanfeng fire by Dr Pearson of xxx, UK, in 2022, he established that the source of the fire was not leaked ammonia, which could not possibly have collected in sufficiently high concentration within the building to have been the culprit. He instead identified the source of fire at an electrical control panel adjacent to the ladies toilet. This was communicated to me by Dr Pearson privately by e-mail.

[xiii] "Ammonia is, in our view, the most likely vehicle of choice for hydrogen transportation because of its high storage density, Ammonia is easier to liquefy -- it liquefies at minus 33 degrees Celsius -- and contains 1.7 times more hydrogen per cubic meter than liquefied hydrogen." https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/natural-gas/

[xiv] 1000 evacuated in Tyson food plant fire, Fire Department: Explosion likely started fire, www.wlfi.com/generic/news/, 5 Mar 2010; Tyson Foods begins Missouri poultry plant expansion, http://www.worldpoultry.net/nr1, *May 1, 2012;* Woody Gottburg, Fire Damages Storm Lake Tyson Plant, Jan 4, 2017; Fire at Tyson Chicken Plant, Employees injured in blaze at Nashville's Tyson plant, Jul 9, 2020, https://www.ktbs.com/fire-at-tyson-chicken-plant/

[xv] Chicken Processing Plant Fires, Hamlet, North Carolina and North Little Rock, Arkansas, US Fire Administration/ Technical Report Series, USFA-TR-057/June/September 1991. Loss Prevention Bulletin of April 2018 as reported in a copyrighted article by the Institution of Chemical Engineers

[xvi] Ibid, A risk analysis of sandwich panels

[xvii] Alliance for the Polyurethanes Industry, http://inspectapedia.com/Energy/Polyisocyanurate_Insulation.htm

[xviii] Popular literature on the subject conjures up the image of cell membranes being pierced by sharp icicles, with the resulting copious loss of cell fluids that it triggers, being the cause of spoilage of meat that is allowed to freeze slowly. While this explanation has the merit of discouraging slow freezing, the imagery is faulty. Ice crystals within animal cells are extremely tiny and they cannot puncture animal cell membranes which, unlike plant cell walls, are not rigid.

Proponents of this analogy would also do well to examine properties of fluids and solids at nano-metre of cellular scale. For objects at the cellular scale cell fluids and water present to them the viscosity of honey and normal movement, drifting and swimming is not possible. That is why bacteria have evolved locomotion alternatives to flagella and cilia. At such relative viscosity levels neither cell membranes nor "sharp icicles" generate the momentum to dash against each other and impart or receive a puncturing-thrust! Cell membranes are damaged by change in surface electrical charge, and for all intents and purposes are rock solid against physical pressure such as can be generated within their nano metre environment. Copious amounts of fluid comes out during thawing or meat simply because water is no longer bound between muscle fibres. This is explained in the next paragraph.

Muscle protein is responsible for a very important property of meat - its ability to retain water and bind added water (water-holding capacity or WHC). Between 84-94% of the water in muscles is free water and this is what gives fresh meat its succulence. This water is not mechanically free to form crystals, as it would be, for instance, in a piece of rubber foam - rather most of it is bound within the myofibrillar spaces. When slow freezing causes changes in the overall intercellular solute concentration and pH, it impacts the environment inside cells as well as outside cells. Both of which release water - not only unassociated water within and outside cells but also bound water, resulting in protein denaturation and so permanent damage to the product's taste. Finally, when thawed, this denaturation water cascades out of the product as excessive thawing loss - which is rich in nutrients and allows rapid spoilage. Additionally it is bad for the product's image.

[xix] Frost heave is a phenomenon affecting civil construction in very cold climates or when sub-zero temperature is made to prevail in large rooms in tropical, temperate or equatorial climates. Consider a large frozen store. Since it maintains a sub-zero temperature the cold creeps down into the plinth and despite the use of floor insulation, progressively freezes the soil under the plinth. Now since water expands upon freezing, groundwater under the plinth freezes and exerts an upward thrust. This results in microfractures in the floor of the frozen store. Should ice on the floor be allowed to melt from time to time, this melt trickles down into the plinth through these microfractures and there is more upthrust. Eventually the flooring cracks up and is destroyed.

There are four methods of solving this problem. The **first** is to build clear off the ground so that air in between the floor bottom and ground creates a thermal barrier and prevents the formation of an ice lens. Aptec does not approve of this method. The **second** method is to lay a grid of PVC pipes UNDER the floor insulation layer and allow circulation of outside air through this grid. The circulating air prevents the ground from freezing up. The **third** method is to embed electrical heating pads UNDER the floor insulation layer. The **fourth** method is to lay a grid of glycol pipes under the insulation and pass a stream of hot glycol through the grid. Heating of glycol is done with waste heat from the refrigeration cycle.