Box building: put to the test

As part of *Container Management*'s 20th anniversary celebrations, two senior container engineers were asked to review the history of container manufacturing. Last month, **David Tingle** and **John Holmes-Walker** considered how box-building became a global industry. In the second of their articles, they focus on the evolution of the container design and construction materials

THE DESIGN OF TODAY'S CONTAINER HAS matured so much that the specifications attached to purchase orders by leasing companies and shipping lines are, apart from certain minor details, very similar. Some owners may disagree with us, but superior specification and performance claims are not uncommon – even today. Our message to these owners and buyers is: Sorry, but your containers are made on the same assembly lines as your competitors, using the same product materials and equipment including the all-important treatment systems and there is little to chose between a brown box, a blue box and a green one! However, several factors have had a significant bearing on container design over the past four decades which we shall now explore.

Corrosion protection

When the steel container industry arrived in Europe from the USA, many small companies were created and they realised that they could become operational quickly with low capital investment by using bought out steel sections, such as tube, RSJs and RSCs, etc. Panels were sometimes flat and reinforced aluminium container style, but joined by welding as opposed to rivets or bought out in corrugated form. Production volume was usually low. Such designs avoided the need for a shear and press shop but often the all-important treatment of the steel and design and construction to prevent corrosion left much to be desired. This led to repair depots having to stock sections in the same way that they were used to for aluminium containers – leading to repair costs which were too high, as were container downtimes.

Many of the smaller producers did not survive, once eventually it was realised by buyers and users that a steel container could be produced while maintaining its structural integrity, by using mostly open sections which could readily be better protected against corrosion. (The IICL did much to promote this formula over many years.) Not only was improved corrosion protection achieved, but a majority of the components used in container construction could be fabricated locally worldwide leading to reduced repair costs. But, the repair costs and downtimes were ever-increasing during the 1970s and beyond, because steel had not been adequately prepared prior to painting and there were far too many cases of premature advanced corrosion leading to many warranty claims as well as a major refurbishment industry for containers worldwide!

Design criteria

International standards, such as ISO, were formulated some 40 years ago and set standards of length, width and height, maximum gross weights and performance requirements to be determined by static testing usually under the control of classification societies such as Lloyds Register, American Bureau of Shipping, Bureau Veritas, etc. Indeed, classification societies world wide were eager to get involved, if for no other reason that the business produced substantial revenues. However, it was the classification societies who defined the pass or fail criteria in testing and designers and the societies have worked closely together to achieve container designs with ever-improving specifications, particularly in terms of tare weight, cubic capacity and cost.

Much credit, though, must go to the buyers and fleet operators of containers for pushing the boundaries of design and standards which eventually become new ISO standards. Examples of this are: the change from the initial 8ft high to 8ft 6ins high, and later to 9ft 6ins high; the change from 40ft to 45ft in length; and for a 20ft box, the change from 20 tons MGW initially, to 24 tonnes MGW – and, to-date, 30 tonnes MGW. Surprisingly, despite the almost universal adoption of the ISO floor test being upgraded by buyers by 33 percent for at least the past 30 years, ISO has only very recently announced that the floor test will be upgraded.

Today's typical 20ft box, while having a MGW of 30 tonnes compared to the original 20 tons MGW, will have a substantially reduced tare weight despite the fact that it is also 8ft 6ins high and designed for 9-high stacking - as opposed to the original 6-high. This has been achieved by research and design and operational experience but certain contributions to the industry, such as Tokyu Car's revolutionary "lazy" side and end wall forms, were a major step forward as long ago as the late 1970s. This design is still the standard for almost all ISO steel containers built today. The reasons for this are that it uses less steel than the previous "square" corrugation, it is the most efficient form of corrugation yet devised thus helping to provide for the increase in MGW from 20 tons to 30 tonnes for a 20ft container, its resistance to damage is superior to other forms of corrugation and it requires less coating material (paint) because the surface area is less than a "square" corrugation.

Roof experience

The early steel containers usually incorporated a flat steel roof and channel-section roof bows and were slightly cambered outwards to try to achieve lateral drainage of water. The roof bows were stitch-welded to the butt-welded panels internally.

Such a design was a rust trap partly because full painting of the roof bows was impossible and roof life in service was unacceptably low. In one case in 1969 that comes to mind we were replacing roofs no more than one year old! So the experience in the field told us that an urgent design change was needed and while experiments were conducted with various forms of roof bows, including attachment by spot welding and adhesive, the corrugated roof in 2mm gauge was born and developed.

Nevertheless, while the corrugated roof has proved to be much more durable, it has not been without its problems which include maintaining a regular camber for water drainage and repairs or replacement in the field because the roof corrugation has closed ends formed during the pressing process. There is still room for improvement in this area.

A significant development in the evolution of container design has been the palletwide containers, which are continuing to become increasingly popular

Palletable

The subject of design would not be complete today without mention of the CPC or CPW - meaning Palletwide container - now available in 20ft, 40ft and 45ft lengths. The development of this type which is basically designed to accommodate all international sizes of pallets while maintaining ISO compatibility in transportation was led by the now defunct Bell Line, with the design later taken over by Cronos.

Sea Containers has designed a product called SeaCell which achieves the same pallet accommodation as the Bell Line version, but in a very different form in that the side wall corrugations are outside the ISO width dimensions but “interlock” with an adjacent similar container. The Bell Line type has slim, but conventional, side wall corrugations outside the ISO width dimensions which do not interlock. Both of these types are becoming increasingly popular because they go a long way towards the fleet owner’s dreams to have the inside of a container (cubic capacity) larger than the outside! As might be expected, ISO regulations have been left well behind with these very applaudable innovations, but with conformity to CSC and classification society rules, there is little doubt that the fleets of these types will continue to grow.

Steel treatment

Materials used for steel containers are of more relevance and interest than the now rarely produced aluminium and GRP containers. Very few GRP containers with steel frames, which were popular in the ‘60s and ‘70s, are purchased today. The main reasons are that they are more costly to produce than today’s steel container; they could not, economically be upgraded to 30 tonnes MGW; and they often suffered from bulging side walls in service.

The topic of steel types cannot be separated from the delivered condition of raw steel and the materials and methods used to prepare the steel substrate for the application of coatings (paint).

In the ‘60s and ‘70s, most of the steel supplied to Europe’s container factories was either hot rolled (surface covered with a very thin film of blue mill scale), or pickled and oiled when the surface was bright and free of surface contamination (apart from the oil to protect the steel during transportation and storage). Manufacturers chose their own method of substrate preparation and consequently there were several different systems adopted. For commercial and logistic reasons, buyers largely accepted what they were offered by the manufacturers.

Degreasing of pickled and oiled steel, usually after the forming process, was often not as thorough as it should have been and paint failures in service due to inadequate degreasing were not uncommon. Some manufacturers even purchased hot rolled steel and attempted to treat it with chemicals in house prior to painting and this also lead to some paint failures in service. Factories such as SNAV and SIC in France and Adamson in the UK invested heavily in chemical treatment plants, but compared with abrasive blasting of dry steel, adopted almost universally in subsequent years, the results were never entirely satisfactory from a container durability viewpoint.

Pickled and oiled steel was eventually outlawed internationally for environmental pollution reasons (the treatment involved surface etching by acids followed by a washing process). Some manufacturers bought bright cold rolled steel but this material was soon found to be too expensive. Others attempted to galvanise complete container steel structures after the assembly process by welding but this was not commercially viable.

Tokyu Car developed an interesting process, whereby buyers thought that they were purchasing containers with an abrasive blasted substrate but in fact the profile on the surface had been achieved by rolling the steel with hardened rolls which had been abrasive blasted. This was more of an embossing process as opposed to abrasive blasting of the steel.

Gradually, abrasive blasting of dry or degreased steel became recognised as the way forward and several systems were employed. Low volume manufacturers usually chose manual compressed air powered blasting of complete steel structures often necessitating several booths. Others such as Adamson pioneered the multi turbine type for blasting a fully assembled steel structure automatically although the interior had to be supplemented by manual abrasive blasting. This system is not suited to very high volume production unless multi abrasive blasting stations are provided.

The system that has become today’s industry norm and probably the most reliable overall, consists of a multi turbine machine for the abrasive blasting of flat steel sheet and plate followed immediately by cleaning and the application of a thin film of zinc rich primer coating material. These machines are also capable of treating components such as 40ft long bottom side rails and are most commonly used for high volume production.

With the latter system, the container is fabricated from zinc primed components and the welded areas are abrasive blasted manually after final assembly with further cleaning and the application of a second coat of primer to follow.

Steel types

We have focused on the subject of steel treatment, but the types of steel generally used in steel container fabrication must also be addressed. The early years saw panels often made from mild steel and frame members made from higher tensile carbon steel. However, by the end of the 1970s the industry had started to consider and use a steel known as Corten, developed in the 1930s by US Steel. This material contains traces of chromium, nickel and copper and has corrosion resistant properties much exceeding that of ordinary carbon steels. It also has higher tensile mechanical properties and was rapidly adopted by the container industry world wide despite the fact that a number of manufacturers initially charged a premium for including it in the buyer’s specification. There have been quite a few sceptics regarding the properties claimed for the material, but there are few, if any, today. Corten and imitations of US Steel’s product is now the principle steel used in dry freight production and nothing better in terms of performance and value for money has been developed in the past two decades.

A more recent development concerns the steel called Domex developed and produced in Sweden. This steel has tensile strength properties at least twice that of Corten and while its initial consideration for use in container construction was far from encouraging, the advent of the CPC/CPW containers has brought it into the market in considerable volume. The CPW/CPC containers are usually 9ft 6in high and have side wall corrugations of reduced depth when compared to a regular full ISO container. Naturally, the operators of such units want to be assured that side wall strength has not been compromised and the use of Domex has allowed this to happen. There are some drawbacks with Domex and the principle one concerns the fact that press tooling designed for, say, Corten type materials will not form Domex satisfactorily because of the much greater springback. Therefore, special tools have to be purchased, but this is not a serious disadvantage considering the advantages to be gained in product performance.

Another type of steel that has been used in the industry is a low grade form of stainless steel known as muffler grade. This has rarely, if ever, been used generally for the construction of all steel containers, but for a number of years was very popular with some shipping lines for the construction of end frames.

Coatings solutions

Manufacturers' commitment to achieving sound steel substrates prior to painting has developed hand in hand with major advances in the coatings or paint industry and its products. 30 and 40 years ago, the container paint industry could well be described as "one long, never-ending, experiment".

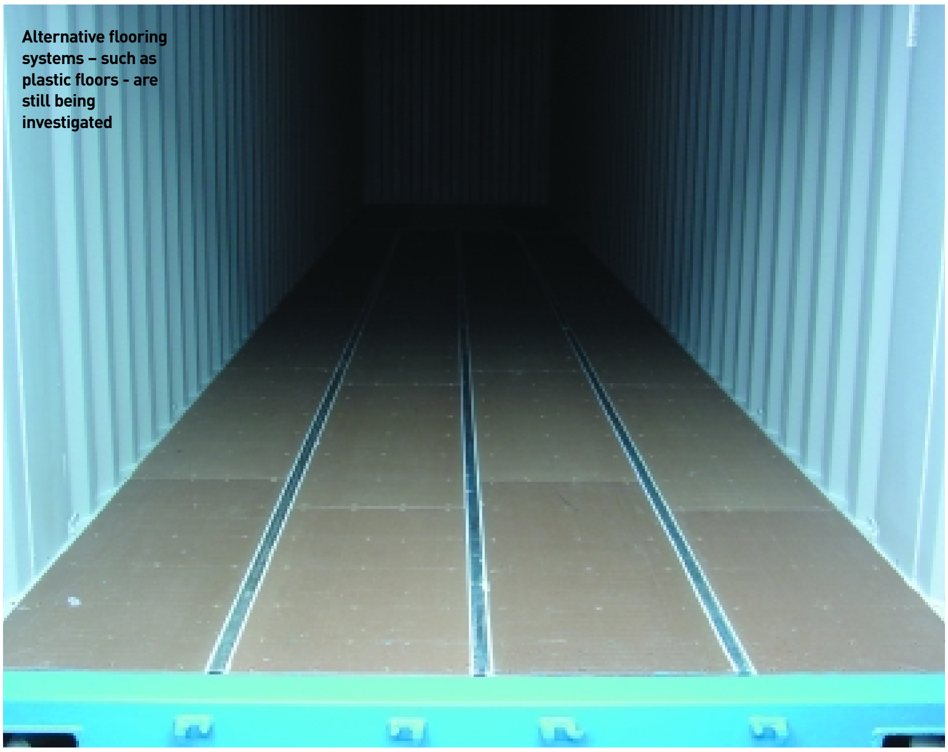
Coating manufacturers, having recognised the revenue potential of the container industry, were climbing aboard wherever they could. Being much involved as engineers with the purchasing programmes at that time, it was often said that a free lunch was available every week with a coatings or paint salesman if one was prepared to forfeit the time! Many coating systems were claimed to have performance or cost advantages. We had single coat systems, two coat systems, 2 pack epoxy paints, PVC material, epoxy ester coatings, polyurethanes and just about every type of paint known to man offered as being suitable for containers.

Various laboratories sprang up to evaluate your chosen supplier's product and application procedure and Konstandt in USA in particular developed a points system for some 12 different tests which, when accumulated, gave a pass or fail mark. However, the analysis of containers which had been in operation for a number of years began to define the best systems combined with optimum substrate preparation. The 3 coat system starting with some 40 microns of two pack zinc rich primer applied in two coats followed by an intermediate coat and a finish coat has undoubtedly won and has been universally adopted. And, at this point it can be stated that the container refurbishment industry, which was so buoyant in the 1970s is now virtually dead thanks to today's superior steels substrate and coatings and maybe, a strong market for used containers but that is yet another story.

Flooring issues

In terms of weight, the material used for container floor construction is second only to steel. By far the most popular material has always been, and still remains, wood; but over the years it has been used in a variety of forms and timber species. The various types include: softwood planks, hardwood planks, softwood and hardwood laminated (Bosdek type, not plywood), Finnish Birch plywood and when Japan came into the business, hardwood in the form of Apitong/Keruing plywood.

In addition to wood floors, we have experienced all-steel floors, steel/wood combination floors, hammock steel floors, rice husk floors, laminated bamboo floors and many attempts to develop alternatives to both wood and steel using plastics and recycled materials. From all the above, only the Apitong/Keruing Asian produced plywood has won general acceptance to date for use in dry freight containers. There are many reasons for this including; some floor types would not reach the required 1.3 x ISO floor strength, some are just too expensive, some could not be produced in sufficient volume, poor wear resistance, replacement difficulties when damaged, attachment problems, instability and last not least, the requirement of many users of containers to be able to nail dunnage to the floor to secure cargo. Apitong/Keruing has therefore maintained its favoured position but at the expense of many who rightly feel very concerned about the deforestation caused by its continuing use



Alternative flooring systems – such as plastic floors - are still being investigated

There is little doubt that when at last, a truly viable alternative to the hardwood plywood is available to all in sufficient volume and at a comparable price, it could well make someone or a company very rich. Only recently, a South Korean company has announced that it is winning acceptance for its plastic floor developed over a number of years, which compares very favourably with the hardwood plywood in terms of weight, cost and performance. Only time will tell if it will be used extensively.

The third and final part of this article will be published in the January/February 2005 issue of *Container Management*, when the Authors will review developments in the technology used to manufacture containers

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From 1968-1980, he was responsible for Sea Container's engineering and technology of containers, special containers, chassis and cranes. During this period started the founding of YMCL and became a director and part of the Sea Containers' management team to create: China International Marine Containers (CIMC), Chicago Marine Containers and Singapore Marine Containers - thus the gravitation to container manufacturing.

From 1980 – 2002, he worked for Tectrans Services Ltd and Tectrans Gmbh - as Managing Director & Engineering Director respectively. He designed the factories and project-managed the creation of HIM Containers in India, TIMCO & QUIC in China and Balmer Lawrie in Madras, India. He also acted as manufacturing consultant to: Xtra, Adamson, Trencor and SeaCold.

John Holmes-Walker D.M.S., C.Eng., M.Mech.E., M R Ae.S. - After spending 20 years in the Aircraft industry, focusing on propulsion systems research and development, John Holmes-Walker joined the engineering department of Sea Containers in 1973. He stayed there until 1992, rising to the position of General Manager – Engineering Management Department. During his time at Sea Containers, his responsibilities included Purchasing and M & R for all container and container related equipment produced or purchased by the company. He also established the company-owned factory to build refrigeration equipment designed by the Engineering Department. For his last six years at Sea Containers, he was responsible all new container projects, and had technical responsibility for the establishment of new company owned factories.

Since 1993, he has run his own consultancy company, Seagull Technology, providing engineering and management services to the container and related industries worldwide.