**Section 1**

## The Load Insulator concept story – idea to reality

It was summer 1992 at the Haydock Equipment Show in the U.K. Tim Whiteman, then Editor of Cranes Today, was entertaining on the double decker hospitality bus. It was the end of the show and Hugh Pratt from Load Monitor had left his own stand and was enjoying a glass of champagne. Tim challenged him, "Hugh, as you are always inventing things, why don't you produce a device which prevents the major cause of crane accidents?" Hugh replied, "It is impossible to make an effective insulating link which has a load bearing capacity of steel and has the insulation properties of glass." This was where the problem was left and Hugh continued with his business.

About six months later Hugh was singing in church, "Praise My Soul, the King of Heaven", and in an instant received the design concept in its entirety for a product which could have the strength of steel and the insulation properties of glass. The next day he contacted his patent agents with a sketch for the idea, from which the patent was drawn up and lodged [35].

### Concept and prototype

Having a firm idea is not the same as making a working unit. The patent covered two design concepts - one used a chain and the other a machined item. The first and simplest way to proceed was to make a simple design to determine whether it had any electrical performance. To this end, a prototype stylised body was commissioned from consultants [68] as a means of holding a structure together and co-linear. A nominal material was selected for an insulator which had some insulating and mechanical properties.

The insulation insert was designed and manufactured [70] and was tested on a tensile tester to determine its strength. A nominal strength of 4 tons was achieved . The prototype unit was submitted to a High Voltage Test [144] laboratory and proved to insulate up to 27kV.

It was clear therefore that it was possible to make a product which had the potential for high strength and electrical resistance. Market research would be needed to determine:

- Voltage ratings.
- Load ratings
- Any standards to which such a product should be made.
- Existing advertised products.

The findings were that no insulating link standards existed as there were no reliable products. One product was being sold at that time, made by Miller. It appeared from the drawings that the Miller unit had several design concerns and the claims of its performance seemed questionable.

**From proto-type to pre-production**

The prototype was based on the first design concept and patent[37]. This achieved a working result but in order to extrapolate it to a heavier rating, it would require special chain links to be made. Such links would make the design prohibitively expensive so the pre-production design was developed around Concept 2 in the patent [41]. This concept was of an insulated link such as in a bicycle chain. The stress levels were carefully designed using regular MathCAD for evaluation and then detailed finite element analysis[87] .

The design stresses were extra conservative and erred on the side of caution. The philosophy being that the extra weight of 150lbs on the end of the hook of a 10t crane is not an important criterion.

It became obvious that to produce a reliable product, substantial investment would be required for development. In order to be reliable no risks can be taken with people's lives. Detailed conversations and discussions took place with a crane company as to what would be considered a suitable device. The conclusions were a request that Load Monitor design such a product to Load Monitor's satisfaction before it be re-presented to the company rather than the crane company specify the design parameters of the product.

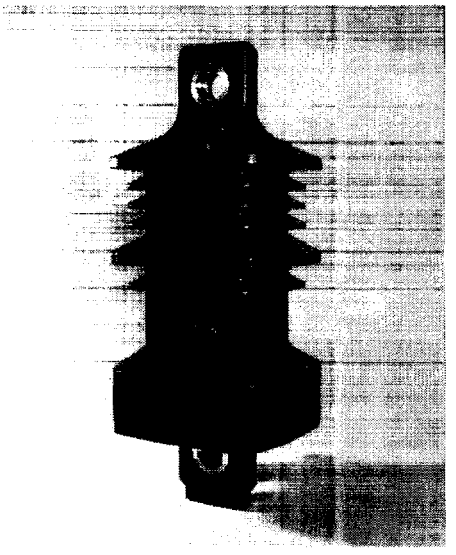
A test schedule was determined to take 20 units and simulate a 20-year life cycle. Under this test would be a combination of Load Monitor and Miller products to compare their designs and the effects that a cyclic life would have on their mechanics strength and electrical resistance.

Load Monitor secured funding for this work which took some time.

After the funding was available, the test schedule started in earnest with a whole series of pre-production and endurance tests. It was quickly shown that the Load Insulator's performance characteristics hardly changed with severe usage giving us confidence to go forward to the production design.

## Pre-production to production

The pre-production design worked. The next step was to invest in computer time to model the Load Insulator with a finite element electrical analysis programme, using LaPlace's equation. This demonstrated that for a few extra dollars, the Load Insulator could be re-machined and slightly modified to result in a 30% improvement in performance[104].



The changes in the Load Insulator were not to its load-bearing design which remained constant but in the size and detail of its flange. This gave a design which was equally strong and electrically resistive in all directions and the increased electrical performance was in the order of +30% - an increase in withstand voltage from 56kV to 84kV.

A further design change for the production item was the encapsulation of the outer skin of the Load Insulator which resulted in another patent [45]. It had been observed in the pre-production designs that the interface between the steel and the polymer could cause separation. The polymer is more flexible than steel and

should always track with it but there was a concern that wicking might cause a problem to deteriorate the Load Insulator. Although this problem had not been observed, it was important that it should be eliminated in the design stage.

The pre-production design also incorporated the self-testing electronics. The final innovation was to eliminate the possibility for electrical tracking around the sheds, or ridges, on the outside edge of the Load Insulator. These needed to be of varying dimensions permitting the Load Insulator to lie in the dirt or the rain and still provide a degree of protection to the smaller sheds or ridges.

**Production**

It was decided to manufacture 10 ton units in a quantity of 50 to determine what first production problems would be encountered. Also, to perform final type testing on the production units prior to sale. Two new moulds were commissioned to meet the production volumes and production commenced.

The design called for a steel body flame cut from plate and then drilled and bored with dowel pins and insulating bushes. The usual issues arose associated with varying quality control standards of the different parts manufacturers. These necessitated the re-working of some of the pins to meet the force-fit tolerances. Since the design calls for no air gaps or voids the force-fit must be correct despite different types of materials being used. The first production run enabled a few teething problems to be sorted on the mechanical assembly.

Some minor problems arose in the component selection for the self-test unit. The design requires encapsulation of the PCB and then to be heated to approximately 110°C when the whole unit is encapsulated in polyurethane. Some pre-production components, polystyrene capacitors, initially appeared to work well but then failed during final encapsulation. Their failure was easily identified during the post encapsulation tests and the units rejected for sale.

The outer encapsulation relied substantially upon previous history of working with a leading expert in Urethane production. A highly polished mould with considerable complexity allowed the whole product to be encapsulated complete with electronics, and all the parts held and jigged during production. The method of encapsulation is guaranteed to exclude voids. Its success has been demonstrated with sawn sections which have not shown any voids in the product. It is remarkable where the fluid will penetrate 0.1mm gaps prior to setting. This has been an important factor in stopping the development of any electric field inside the Load Insulator which might precipitate a breakdown.

**Final type testing**

It was now certain that the production model would carry the working load and resist the voltages found on 98% of the power lines hit by cranes. The final tests

to be performed at independent test houses needed to verify some worst-case scenarios. It was important that the test schedule should be particular so that one parameter was varied and the others held constant to see if any effect was caused by such a problem.

The independent test house at Southampton University was employed to carry out a series of standard type tests for Load Insulators, simulating artificial rain, voltage withstand, impulse withstand and salt fog. The protocols for these tests gave us a very conservative margin for error in that they had been designed for insulators normally always on, constantly being fried.

## The future.

The future must be to engage with a sceptical lifting industry already disappointed by the unsupported claims of previous manufacturers of Load Insulators. The educative process should allow contractors to add an effective product to their safety toolbox reducing the main cause of crane accidental deaths.