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Remote Plant Plays Key Role in ABB Insulator Business

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Photo: Courtesy of ABB Plast

The reindeer country in the far northern reaches of Sweden is not exactly the type of place where one might expect to find a supplier of strategic components for HV networks.

However, tucked away in Piteå, a town located in a region near the Arctic Circle and where trees, rivers and lakes far outnumber people, is ABB Plast - a factory supplying the hollow core composite insulators which are now finding increasing application on electrical networks worldwide. One of many production centers within the huge Swiss-Swedish multinational, this particular plant has actually been in existence since the mid 1960s - well before Asea and Brown Boveri merged to form ABB.

In this article, INMR Contributing Editor Dr. Claude de Tourreil, travels to visit what may well be the world's most northerly factory in the field of HV engineering and reports on this facility's products as well as manufacturing technology.

Producing highly-specialized insulators in northern Sweden and at quite a distance from many of the manufacturing facilities which utilize them in HV apparatus might at first glance seem a strange policy for a prominent multinational such as ABB. Yet, as Roger Sundqvist, Plast's Manager of Marketing and Sales explains, the decision to locate all production of hollow core composite insulators in Piteå was actually quite a logical one given the plant's unique capabilities.


Photo: INMR©

Sundqvist. Now promoting insulator sales outside the ABB Group.

"The Plast organization," says Sundqvist, "has been involved for many years in manufacturing pressure vessels as well as molded and injected plastic components used in a variety of industries. Therefore, when ABB decided to go into the large-scale manufacturing of hollow composite insulators, it made sense for our plant to be selected as the sole production center."

In point of fact, the process of ABB's entry into the business of supplying hollow core composite insulators actually began long before the first such unit ever rolled off the production line in Piteå.

To begin with (as reported in past issues of INMR), scientists at ABB Corporate Research in Sweden devoted several years of development work during the mid 1990s aimed at evaluating the relative electrical performance of various silicone formulations as well as reviewing alternative insulator production technologies. This work helped to clarify the requirements for what would be regarded as the ideal silicone material for the special production process ultimately selected.

The process of ABB's entry into the business of producing hollow core composite insulators began long before the first such insulator ever rolled off the production line in Piteå.


Photos: INMR©

Executives from other ABB companies in Ludvika examine new composite insulator with obvious interest.

Then, in mid 1998, the first small-scale pilot plant for insulators was established in Ludvika, Sweden amid much internal fanfare (see INMR Vol. 6 No. 3). At the plant's inaugural ceremony in the Spring of that year, key personnel from all of ABB's nearby manufacturing centers for HV apparatus were invited to tour the new facility. Management at the new pilot plant used this opportunity to put forward their arguments about all the potential benefits of replacing externally-purchased porcelain with the new, internally-produced composite insulators.

Plast had, by this time, in fact already started to play an important role in ABB's insulator business, being the sole supplier of the fiber-reinforced plastic (FRP) tubes used by the new Ludvika facility.

Over the years, it became increasingly apparent that adding the silicone housing onto these tubes was a step which might more efficiently be performed at the same location where the tubes were themselves being manufactured.

Says R&D Manager Anders Strömbeck, "Plast already had the expertise necessary to manufacture the FRP tubes. All that we needed therefore was to incorporate into our facility the special extrusion molding technology used to apply the housing to the tube. The strategic decision was therefore made to focus all of ABB's production of insulators in Piteå."

Generally-speaking, a production facility for hollow core composite insulators is much more compact than would be required to manufacture equivalent insulators made of porcelain. This is because the manufacturing process involves far fewer steps - a fact which becomes very evident when moving through the Piteå plant.

Strömbeck explains that all incoming raw materials needed for manufacturing these insulators are checked for conformity to Plast specifications. In the past, this was already routine work for the production of the FRP tubes. Now, a similar procedure has also been established for the high-temperature vulcanized (HTV) silicone rubber used in the external housing.


Photo: INMR©

Strömbeck. Insulators benefit from an efficient and cost-effective production process.

For every given epoxy formulation and type of glass fiber, a change in the sizing of these fibers can result in FRP tubes having very different mechanical and electrical performance.

Photo: INMR ©

Winding machine for 4 meter tubes.

Photo: Courtesy of ABB Plast

Mandrels for manufacturing FRP tubes (in background stands 7 meter long winding machine)

According to Strömbeck, a decision was made to work with two different silicone suppliers so as to best ensure an uninterrupted supply of this key strategic and what he says is a relatively costly material.

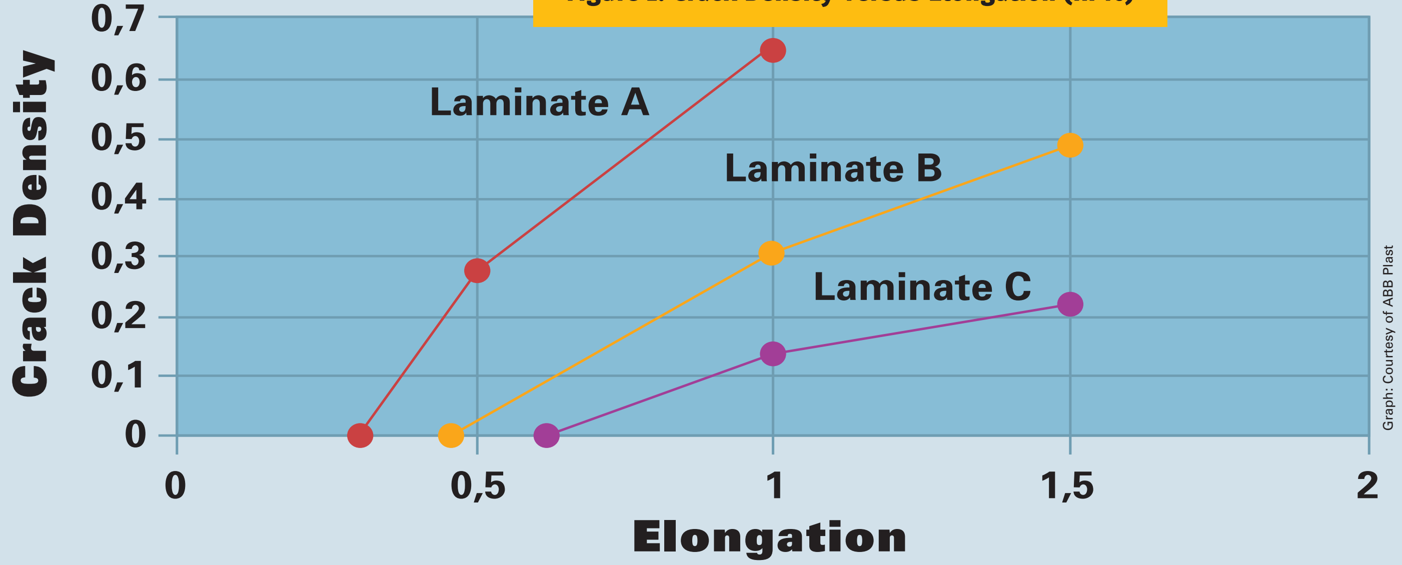
The Piteå plant is set-up such that there are two separate winding stations to produce the FRP tubes which form the core of each insulator. One station can simultaneously accommodate two 4 meter-long steel mandrels while a second winding machine can produce tubes of up to 7 meters in length. The parameters of the manufacturing process for each tube can be adjusted so as to obtain exactly the mechanical performance required from each insulator in its final application.

This is accomplished mainly by selecting the correct angle for winding onto the mandrel the glass fibers which have been pre-impregnated with resin. The thickness of the tube wall also influences its final mechanical strength.

After the impregnated glass fibers have been wound onto the mandrel, the entire unit is placed into a curing oven where polymerization of the epoxy resin takes place. As the mandrel moves through this oven, it is subjected to various levels of temperature and controlling this temperature profile is apparently quite important in obtaining a consistently high quality tube.

Another key production variable is the sizing of the glass fibers themselves so as to ensure

Figure 1: Crack Density Versus Elongation (in %)



Graph: Courtesy of ABB Plast

Using only one dye placed on the head, the special extrusion machine can produce a wide range of insulators with different diameters and lengths.

IEC electrical test of FRP tube sample after boiling.

Photos: Courtesy of ABB Plast

Set-up for IEC boiling test of FRP tube sample.

optimum bonding between them and the resin. Says Strömbeck, "the specific type of glass fibers and epoxy resin used to manufacture tubes are certainly important in ensuring high performance. However, for every given epoxy formulation and for every type of glass fiber, a change in the sizing of these fibers can result in FRP tubes having very different electrical and mechanical performance."

Strömbeck goes on to explain that the quality of the fiber-resin interface is a determining factor affecting the mechanical stress level at which micro-cracks will appear when the insulator is placed under mechanical loads. On a microscopic level, this is basically equivalent to the damage level concept used in the IEC 61462 standard.

Indeed, mechanical testing of FRP samples having different resin to glass fiber bond strength clearly demonstrates the influence of sizing on the appearance of such micro-cracks.

FRP tubes can be manufactured to have cylindrical, conical or even barrel-like shapes so as to best adapt to the type of apparatus component which will be placed inside them. When the silicone material is extruded onto and bonded to the tube in a later step, the resulting finished insulator maintains exactly the same shape since the housing follows all the contours of the tube.

The quality of every tube is then verified using various IEC-specified tests as well as other testing procedures developed in-house. Finally, the tube extremities are machined to receive the flanges which are glued onto both ends.

The next operation in the production process is performed in an atmosphere-controlled chamber where a special primer is applied to the surface of the tube in preparation for the next major production step. The tube is now ready for the external silicone housing.

Strömbeck states that the production technology selected by ABB for application of the silicone onto the FRP tube - an extrusion process in which the housing is helically wound onto the tube - is especially interesting inasmuch as it offers several important production advantages. The shape of the sheds, a key factor influencing the insulator's electrical performance, is then determined by the design of the extrusion head.

According to Strömbeck, this production process, which he indicates has now been patented in many countries, is a very efficient and cost-effective way to apply the housing onto the FRP tube. This is because the special extrusion machine can employ only one dye placed on the machine head to produce a wide range of insulators having different diameters and lengths. This contrasts with one of the main alternative production technologies for hollow core composite insulators which

Preparing extremities of tube to receive flanges.

Photos: Courtesy of ABB Plast

Extrusion of helical silicone housing onto tube.

Photo: INMR ©

Blue door of a curing chamber and insulators destined for the Three Gorges Project in China.

Photo: Courtesy of ABB Plast

Checking conformity of flange position.

Insulator bending test.

Photos: Courtesy of ABB Plast

Preparing an insulator for bending test.

Up to now, hollow core composite insulators have most typically been used as a direct one-for-one replacement for porcelain.

Photo: Courtesy of ABB Plast

Chamber for pressure and tightness testing (in background).

requires expensive new moulds for every different tube diameter.

After extrusion, the housing is cured in an oven after which the manufacturing process is essentially complete. However each insulator still has to go through a series of quality control checks.

For example, the main dimensions of the unit as well as the parallelism, co-axiality, concentricity and eccentricity of the flanges are verified. Moreover, every insulator is subjected to a mechanical bending test in which a cantilever load is applied to one flange while the other is solidly fastened to the test machine.

If required by the apparatus of which it will become a part, the insulator may also undergo a pressure test. While the insulator is under internal pressure, a tightness check is performed to test for leaks using a mixture of air and hydrogen.

The finished insulators are then shipped to various OEM customers where they will become an integral part of a range of HV equipment and components such as circuit breakers, bushings, instrument transformers and cable terminations.

Although the technology behind hollow core composite insulators has existed for more than 20 years now, the process of its broad acceptance by electric utilities has taken a very long time and much longer than was the case for insulators used on overhead lines. This, in turn, has made most electrical apparatus OEMs reluctant to commit too intensively to this technology, preferring instead to let the final customer decide on choice of insulator type in each case.

Indeed, the fact that the end user of apparatus is typically not in direct contact with the manufacturer of the composite insulator is seen by some in this industry as having played an adverse role in the extent of market penetration of this technology.

Another factor which was not helpful in the process of rapid market acceptance was the relatively long time it took to issue international documents and standards for these types of insulators.

IEC Technical Report 61462 was published in late 1998 and used by some in the industry as a Standard. However, this was already more than ten years after these insulators had first been developed and marketed.

Photo: Courtesy of ABB Plast

Pressure and tightness testing.

With a fairly large production capacity now in place, Plast will put a significant effort to promoting sales to other OEM customers, even if they might be competitors to ABB.

An IEC Standard governing hollow core insulators is not expected before the end of 2006.

“Hollow composite insulators have several distinct advantages over porcelain in terms of performance,” claims Strömbeck. “They are quite light and therefore ideal for use in areas prone to seismic disturbances. Also, because of the hydrophobic properties of their silicone rubber housings, they perform well under polluted service conditions. In addition, if a shed is damaged, depending on the type and location of the damage, it can be repaired.”

Safety, according to Strömbeck, also favours composite insulators for equipment applications.

“An exploding porcelain shell due to vandalism or an internal problem,” he says, “can be lethal because of the sharp pieces ejected at great velocity. By contrast, composite insulators are much safer because they just tear open under such circumstances.”

Another factor, adds Sundqvist, relates to production lead times. “Hollow composite insulators,” he remarks, “have a very short delivery time compared to porcelain. This can be a real advantage in present market conditions where inventories are kept as low as possible.”

The utility marketplace is today extremely conscious of costs and therefore pricing of insulators takes on a more crucial role than perhaps ever before.

ABB Plast manufactures hollow core composite insulators for apparatus from 145 kV to above 500 kV. Sundqvist acknowledges that for voltage levels below 230 kV, these insulators may have some difficulty in competing price wise with porcelain alternatives, especially when these come from Asia. At the same time, he emphasizes that for voltages higher than 300 kV, the pricing of composite insulators is today very competitive.

Until recently, nearly all the insulator production of Plast has been sold to other ABB units, not only in Europe but also in Australia and to a large extent in the United States. Now, with a fairly large production capacity in place, Sundqvist indicates that he will put a significant effort to promoting sales to other OEM customers, even if they are competitors to ABB.

Asked about possible product or manufacturing developments in the future, Strömbeck replies, “we really do not see any radically new hollow core composite insulator designs emerging over the near term. Rather, we believe that by optimizing the present design and production process we will be able to reduce production costs.”

Up to now, hollow core composite insulators have most typically been used as a direct one-for-one replacement for porcelain. In this respect, says Strömbeck, it has not always been possible to take advantage of the full potential of this technology in terms of allowing for radically new and innovative equipment designs. To remedy this shortcoming, Sundqivst and Strömbeck believe that in the future OEMs and manufacturers of these insulators should work more closely together in order to realize all the possible benefits offered by this technology. ☒

Photo: Courtesy of ABB Plast

New 400 kV breaker incorporating composite insulators.