PIN INSULATORS: WHY THEY MAY FAIL

Authored by: Charles Clement, Ph.D.

Material Differences

Hendrix polymer insulators are produced by the injection molding process of high density polyethylene (HDPE), an organic based material. Organic materials have a melting temperature typically below 600F. Polymers are synthetically produced and their quality and technical properties are very consistent from one batch to another. HDPE is light weight and does not chip, crack or break easily.

Porcelain is an inorganic material made from natural raw materials (Clay, feldspar, Kaolin etc…). These natural materials are combined with water, formed and fired. The quality and technical performance of porcelain is inconsistent and varies from batch to batch and from one supplier to another. Porcelain is heavier than HDPE, and is very brittle and can break easily upon mechanical or electrical impacts.

Reasons for Failure

1. **Incorrect Insulator selection**

   Hendrix HDPE pin insulators are designed to exceed the American National Standard Institute's (ANSI) electrical and mechanical requirements. Among several electrical requirements, ANSI dictates the Critical Impulse Flashover Value (CFO) per insulator class. ANSI does not classify insulators by voltage class. It is incumbent upon the electric utility to select the appropriate insulator for their overhead distribution system. Each overhead circuit has a Basic Insulation Level (BIL). The selected insulator has to maintain the system designed BIL. As a general rule, the insulator BIL is estimated to be 90% of its CFO. Selecting an underrated insulator can result in failure.

2. **Insulator Overtightening**

   a. Hendrix HDPE insulator: An improper installation may result from over-tightening the insulator onto the mounting pin. HDPE insulators require no tools for proper installation. Hand tightening is sufficient. When over-tightening or tools are used, the insulator neck area can be mechanically stressed, resulting in the formation of a radial crack instantaneously or over time. The crack typically initiates from the insulator threads radially outward. Indications of stress include white stretch lines or cracking along the neck of the insulator or saddle. Once energized, the insulator may provide years of service as the remaining neck insulation thickness is sufficient for the applied voltage. Should an extreme voltage spike occur, the remaining insulation thickness can be breached and cause failure. The insulator generally remains intact on the mounting pin. Complete melting can occur if excess energy remains on the circuit.

2a. Overtightening Stress Crack

b. Porcelain pin Insulator: over-tightening causes the insulator to break during installation or can result in a partial radial crack. In the case of an extreme voltage rise, the remaining insulation can be breached and result in failure in the same manner as HDPE. However, porcelain will break and shatter causing the mounting hardware to be exposed to the energized line.

Image 2b: Flashover

3. Lightning – Voltage Surge and magnitude

Lightning is a current generator. 70% of the 25 million strikes/year in the U.S. have an average stroke current of 35KA. Lightning causes severe voltage surges in electric overhead systems. The current magnitude of the stroke, the BIL of the insulation system and the surge impedance determines the maximum voltage of the surge. These voltage surges last a few microseconds, but can reach thousands of volts with arc temperatures beyond 2,500 degrees. The insulator itself does not draw lightning to it, lightning is drawn to the ground or grounded structures via the path of least resistance. To get to ground, lightning strikes may travel great distances through conductors, insulators, hardware and finally to ground.

When a voltage surge discharges or "flashes" over the insulator or is partially diverted to ground by an arrestor, a chopped waved may continue to propagate along the line. Poor Structure and equipment grounding may result in limited energy discharge where high energy remains in the chopped wave. This remnant wave has enough energy to cause additional damage to unprotected equipment. A proper system design with adequate grounding and surge protection may improve the reliability of the system against voltage surges especially induced by lightning. Lack of arrestors in the surge path or lack of proper grounding can result in lightning surges (travelling at ~1000ft/µsec) that remain severe enough to cause system damage.

a. Hendrix HDPE Insulator: Each pin insulator class has a critical flashover value (hence a BIL). Should the surge voltage reaching the insulator have a magnitude below the BIL, flashover or partial discharge will occur, dissipating the surge and the system will continue to operate normally. If the surge voltage magnitude exceeds the insulator BIL and has an excessive rate of rise, the insulator can either fail (puncture through the head area) or flash over in order to get to ground. Whether the surge flashes over or punctures the insulator can depend on factors such as air quality, contamination, humidity levels, speed and energy of the surge. If the strike punctures the insulator, it is possible that the resulting extreme temperature of the arc (>2,500F) can partially or completely melt the insulator.

Image 3a: Example of Flashover

b. Porcelain Insulator: For every ANSI class, porcelain insulators have a lower critical flashover voltage value (hence BIL) than the equivalent Hendrix HDPE insulator. If the surge voltage magnitude exceeds the insulator BIL it can either fail (puncture through the head area) or flash over in order to get to ground. Porcelain will shatter into pieces creating hazardous and dangerous safety concerns to personnel and equipment. Partial discharge or flashover can also occur. In some situations, the flash over arc is powerful enough to cause pole fires damaging the wood or fiberglass epoxy cross-arm, pole and surrounding property.

4. <u>Blue Sky failure</u>

Image 3b: Flashover

At times a chopped wave, a transient or a switching surge can have enough energy to puncture the head of an insulator (small pin hole path) with no other visible damage. The system can still operate normally. Over time with temperature variations, moisture migrates into the pinhole puncture path and increases its conductivity. A leakage current then starts to develop through the pinhole path to the mounting pin. Should the leakage current continue, the conductivity path increases and can develop into a sustained Arc.

a. <u>Hendrix Insulator:</u> The high temperature arc can melt a path (up to 3/4" diameter) into the insulator saddle or neck. In some cases a sustained arc will also melt the mounting hardware.
b. <u>Porcelain Insulator</u>: The porcelain insulator will behave similarly to the Hendrix Insulator except that it does not melt or burn. It becomes mechanically weakened and will degrade and break apart.

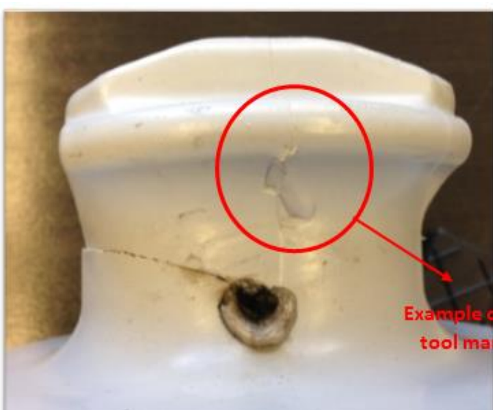

Image 3c: Puncturing as a result of overtightening

3d: Overview of puncture

Authored by:

Charles Clement, Ph.D.

Charles Clement, Ph.D.
Director of Engineering
Hendrix Molded Products

Report by Charles Clement, Amherst, NH on 6/8/2017

Hendrix Molded Products 116 Route 101A Amherst, NH 03031
Tel: 603-673-2040 Fax: 603-673-1497 E-mail: molded@hendrix-wc.com Website: www.HendrixHPI.com
A Marmon Wire & Cable / Berkshire Hathaway Company