Ease of EHV live-line maintenance by design

of structures, hardware, hot-line tools and polymer insulators

Overview

When you consider design enhancements to a new EHV transmission line which can make it easier and more efficient to maintain by hot-line methods, these are the major concerns:

• Structure and line hardware • Hot-line tools and attachments • Polymer insulators

Structure and line hardware

As a first step, consider why the fitting or retrofitting of structures is important to maintenance.

The "Whys"

By integrating maintenance aspects into the structure design planning stage rather than as afterthoughts, safety and efficiency can increase. Clearances can be pre-established, and working ease can be assured through scaled layouts utilizing human factor considerations. This should encompass the structures, insulators, hardware and tools to be used and the approach interfaces of these with the lineworkers (accessibility, steps, hand holds, platforms, attachments, weight, visibility, etc.).

If the structure and approach equipment are properly designed and fitted, work procedures will be more uniform throughout a system.

The "Hows"

To achieve maximum benefits from structure fittings specific to live-line maintenance, concentrate on three areas:

• Clearance • Interface • Accessibility

OSHA-Required Clearance for live-line maintenance should be basic to the initial structure design. Among considerations for clearances are those for climbing, getting into position, locating and handling tools, performing routine and special maintenance, removing tools and return of workers to the ground. Terrain, weather and laws may dictate or restrict equipment and procedure, but all possible application methods should be considered and incorporated so that accessibility is not restricted.

The human factors of stance, visibility, reach and movement also must be considered to ensure clearances for all maintenance operations. The design must address clearances relevant to the arm, window, waist, Vee string, I-string, insulator swing, tangent, running corners, deadend, bucket truck, barehand, ladder, sticks, etc. Structure designs properly incorporating allowances for these clearances provide an environment which promotes safe, efficient and expedient live-line maintenance.

Interfaces between structures and tools are subtle to anyone lacking hands-on experience with live-line maintenance. Without special attention during hardware design, the maintenance tools must then be developed around the hardware and may require excessive weight and complexity which hinder efficient operations. The benefits of specific structure-to-tool interfaces are best illustrated by options on insulated strain sticks and yoke assemblies, as follow.

The hardware of a twin insulator string with no special maintenance interfaces is shown in Figure 1A. One method of mounting a tool assembly is illustrated in Figure 1B, where the tool uses hardware shackles as bearing points. This has the drawback of making it difficult to remove and re-install polymer insulators or porcelain insulators on each end of the string.

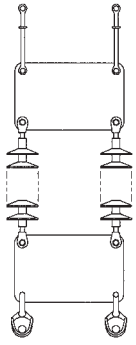


Figure 1A

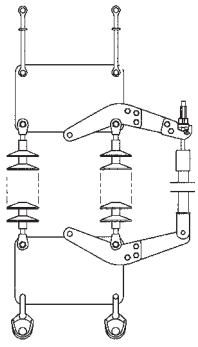


Figure 1B

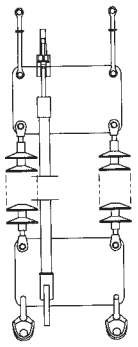
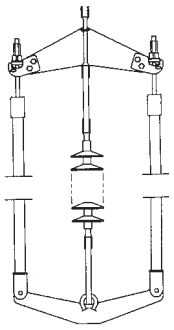


Figure 1C



Side View

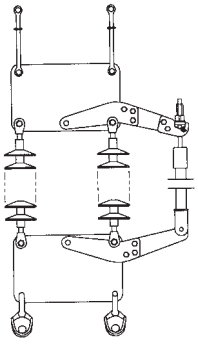


Figure 1D

Another tool assembly shown in Figure 1C illustrates bearing points remote from the shackles. This tool will perform adequately, but lacks precisely defined interfaced locations which are desired. The resultant strain stick length is also longer than could be realized with other designs.

Holes added to the hardware design can provide precision in tool locations, as illustrated in Figure 1D, but make it difficult to remove and re-install polymer insulators or porcelain insulators on each end of the string.

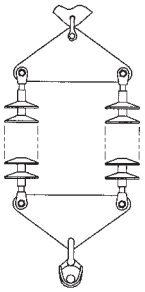


Figure 2A

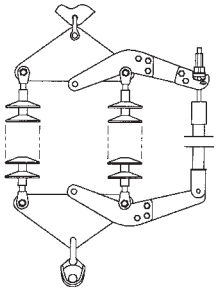


Figure 2B

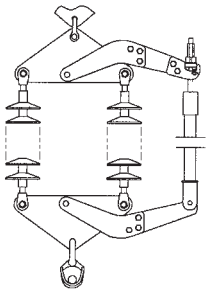


Figure 2C

Figure 2A illustrates another set of hardware with no special incorporation of live-line tool locations or bearing points. Tools capable of working this string are shown in Figure 2B, which again shows the problem of bearing on the shackles. Figure 2C shows the pin and bearing plate tool that gives well-defined locations without bearing on and interfering with shackles of the insulator string.

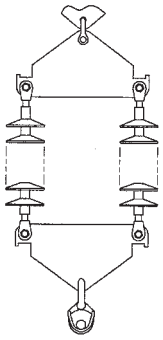


Figure 2D

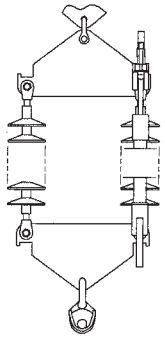
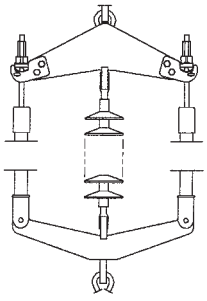


Figure 2E



Side View

Figure 2D shows another approach to hardware design where notches are used to precisely locate the tools, as seen in both Figures 2D and 2E. The choice of single strain poles on double strain pole tools is dependent upon loads encountered and on desired accessibility for use of an insulator cradle or other tools.

Hot-line tools and attachments

Tabs placed on the arms of steel poles can be of great help in locating tools. The holes in these tabs serve to allow pinning of the yoke plate for security. This is illustrated in Figures 3A and 3B.

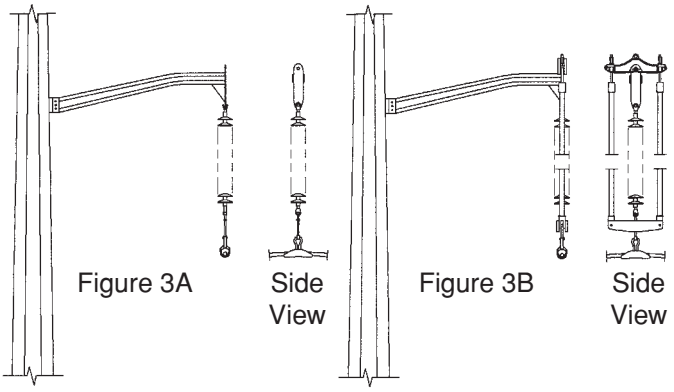
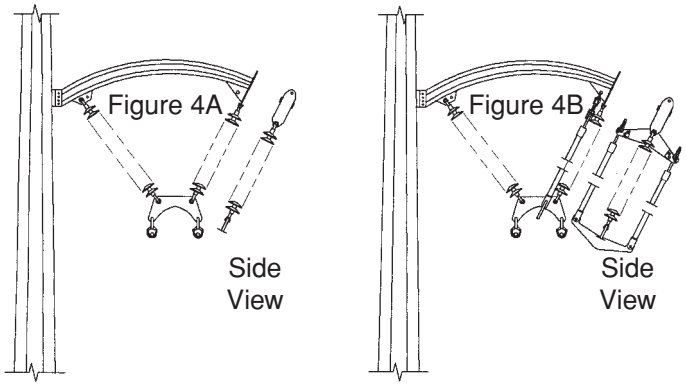


Figure 3A Side View Figure 3B Side View

Gussets and holes can be used as a means of positive location and captivation for the yoke plates as shown in Figures 4A and 4B. The use of tools with this type of captivation can be widely applied to avoid special limited application tools.



Links can be utilized to provide specific location for tool-to-hardware interfaces. Both cold-end and hot-end links are illustrated in Figure 5A.

How the tools interface with these links is shown in Figure 5B.

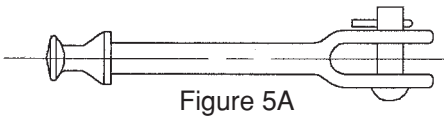


Figure 5A
Hot Line Clevis Link

Reduction of loads on booms and cradles can be achieved by using links to permit handling of half the insulator string at a time.

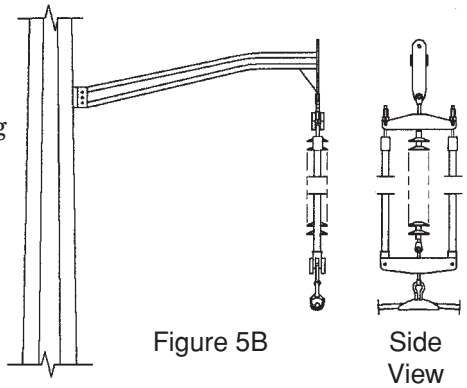


Figure 5B Side View

Corona ring considerations become significant on higher-voltage systems since either the rings must be removed or special tools fitted to avoid interference. Some dimensions to be considered are shown in Figure 6A. In addition to the relationships shown, allow for fitting the insulator cradle.

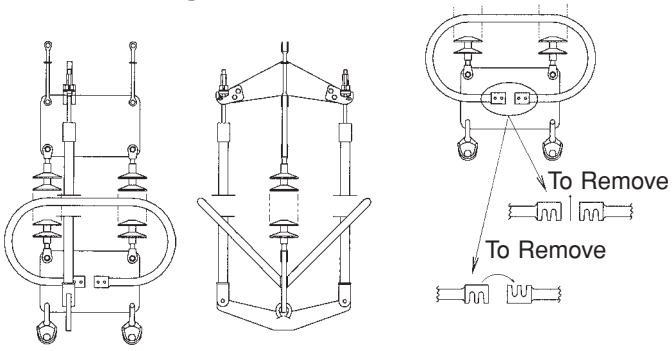


Figure 6A Side View Figure 6B

If removing the corona rings is the method chosen, consider slots rather than holes to permit removal and replacement without fully removing the bolts. See Figure 6B.

Accessibility considerations include basic approaches such as pole steps (permanent or removable) as shown in Figures 7A and 7B.

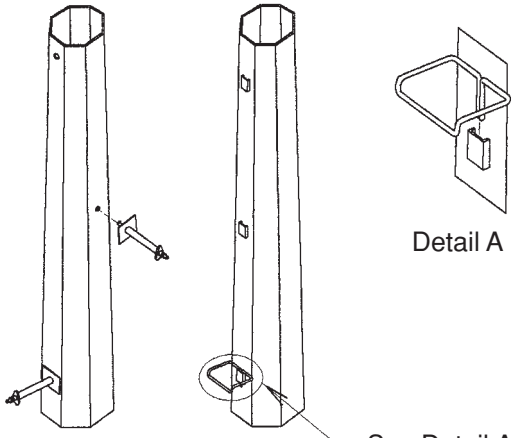


Figure 7A Figure 7B

Polymer EHV insulation

As of 1997, US and Canada utilities had completed 164 lines using polymer Ohio Brass® Hi*Lite® insulators. Another 16 countries also are using Hi*Lite insulators.

Since the advent of polymer insulators, Ohio Brass has developed state-of-the-art weathershed materials for suspension and deadend insulators. Polymer insulators merit consideration for several reasons: Ease of construction, lower RIV and corona, better contamination performance, vandal resistance, visual acceptability and reduced maintenance costs.

Because of Hi*Lite's durable fiberglass-polymer composition, these insulators are virtually unbreakable. Much of the installation work can be done on the ground without concern for chipping or breaking the insulators. Construction and maintenance crews can work faster because Hi*Lite units are easy to handle on the ground and on the tower. They weigh 90 to 95 percent less than their porcelain or glass insulators. Porcelain and glass break easily, while the Hi*Lite insulator is extremely rugged. The fiberglass core is strong and elastic; the weathersheds are flexible and unbreakable.

These insulators reduce maintenance costs by discouraging vandalism damage because they are smaller targets and do not chip, shatter or explode when hit.

Polymer insulators are more economical to install and maintain. They cost-effectively solve design and operating problems due to their higher strength and superior damage resistance.

Figures 8 and 9 show typical double- and triple-deadend strings — one with porcelain insulators and the other with polymer Hi*Lite units at a fraction of the weight, requiring less rigging and no cradle with boom, etc. for insulator changeouts. Each cargo boom requires bracing to the tower legs to support the extreme weights involved with porcelain insulators. A polymer one-piece insulator can be handled with a link stick and hand-line rope. Without the many porcelain insulator joints, the job can be completed in the most effective time possible.

Some recent approaches include large rings encircling the pole for footings and accessibility around the transmission pole. This ring can also serve as a part for ladder captivation and additional accessibility as shown in Figures 7C and 7D.

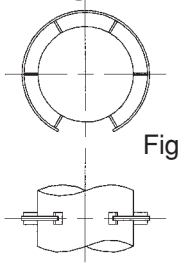


Figure 7C

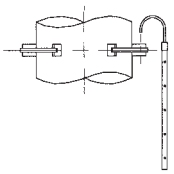


Figure 7D

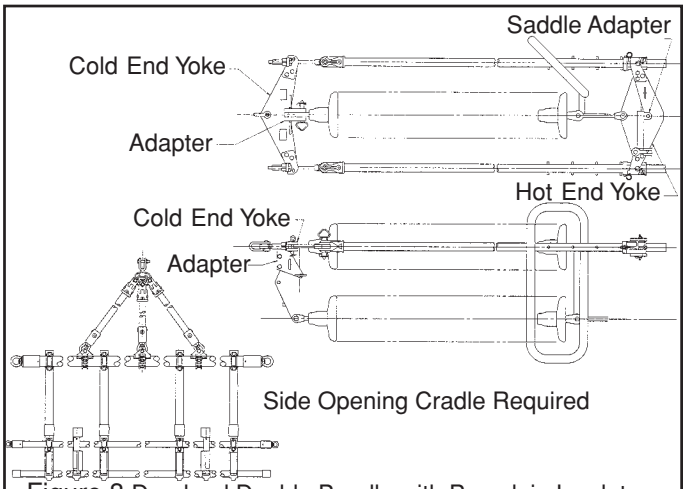


Figure 8 Deadend Double Bundle with Porcelain Insulators
Insulator Weight – 350 lb.

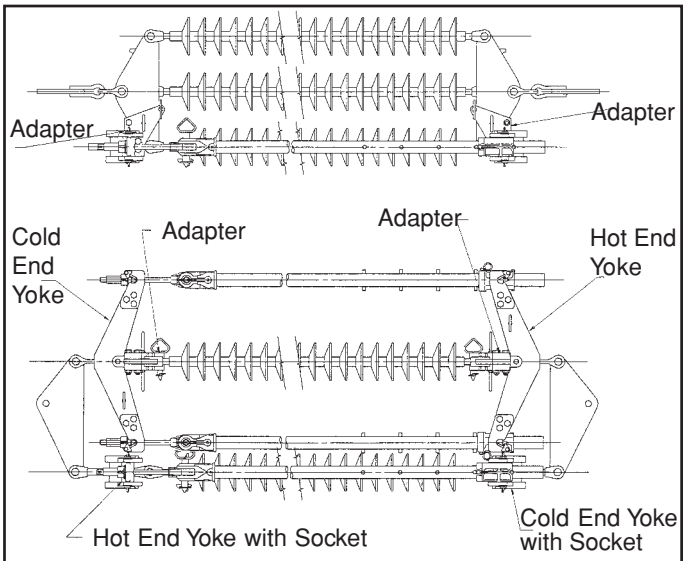


Figure 9 – Deadend Triple Bundle with Polymer Insulators
(No cradle required) Insulator Weight – 35 lb. each

Conclusion

Hubbell Power Systems highly recommends that customers considering construction or retrofitting of a transmission structure or line take into consideration all of these suggestions during the design-planning stages. Preplanning for EHV maintenance can save a tremendous amount of time and dramatically advance line-crew safety when live-line maintenance is required.

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Tips and News, Vol. 1, No. 2, April 1995. Bulletin No. 7-9501.

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