TTCI TECHNOLOGY DIGEST

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The work described was performed by Transportation Technology Center, Inc.. a wholly owned subsidiary of the Association of American Railroads.

Imaging the Draft Key Retainer/Cotter Pin

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Key Findings:

- Machine vision image analysis requires objects of interest to be visible within the field of view.
- Camera position determines line-of-sight visibility.
- Line-of-sight visibility affects capability of machine vision algorithms for inspecting draft gear retaining components.
- Cut levers, air hoses, and framework on the carbody can block key components of the coupler securement system on E type couplers.
- The cotter pin on the draft key retainer is most visible with cameras placed slightly above and with a downward angle relative to the draft key.
- There may be no single camera placement that works well for every car type.

Transportation Technology Center, Inc. (TTCI) performed a camera placement study to determine optimal camera positioning for inspecting the cotter pin on the draft key retainer of E type couplers. The study tested different camera distances, angles, and heights over a variety of car types to find the best camera positioning for viewing the cotter pin. Placement of cameras is key to machine vision inspection of components in the train. By moving the camera and documenting position, this study recommends camera placement for inspecting the coupler securement on E type couplers for multiple car types.

The primary requirement for machine vision (MV) inspection is that the component of interest be visible in the image. Lighting, resolution, and field of view all play a role, but the component of interest must be visible on a line of sight. Components such as car frames, ladders, air hoses, and cut levers can interfere with the inspection by blocking the object of interest. Camera placement is fundamental to algorithm performance and sub-optimal placement compromises performance of automated detection. Traditionally, camera placement represents a compromise, presenting a generic view that may not have been optimized for any specific component. This study, funded by the Association of American Railroads' Strategic Research Initiatives Program, was undertaken to improve the view of the cotter pin on the retainer of E type couplers. This component was selected for investigation at the request of the Technology Driven Train Inspection (TDTI) Technical Advisory Group (TAG).

TEST SETUP

A high resolution digital camera on a tripod was used to photograph the components of interest. Camera position is described relative to a datum point on the rail. A laser distance measurement device and measuring tape were used to measure camera placement. Bubble levels attached to the tripod were used to make sure the camera was level. The tripod also has markings to measure tilt (angle) and rotation. Initial camera distance from the rail was 8 feet, which is sufficient for plate clearance and typical of existing MV camera distance.

OBJECTIVE

The objective of this study was to identify optical paths for best viewing of components and to establish camera positions that can view the components of interest on all car types. The deliverable was defined and documented camera locations providing line-of-sight visibility for coupler securement components. Figure 1 shows the camera and tripod arrangement.

Figure 1. Camera on tripod positioned with respect to top of rail

This *Technology Digest* considers the draft key retention components for E type couplers. Figure 2 shows the draft key and the draft key retainer. Of particular interest is the cotter pin that holds the draft key retainer in place. The cotter pin must be securely in place to assure security of the assembly.

Several camera views may be required to image a given component on different car types. TTCI attempted to identify the lowest number of camera views needed to image the draft key retainer and cotter pin across a variety of car types. TTCI also sought instances where it was not possible to place a wayside camera to view a component — such will be the case where no straight line of sight exists between the component and feasible camera placement points. It is presumed that cameras will be mounted stationary on the wayside. Robotically controlled camera gimbles were not considered in this study.

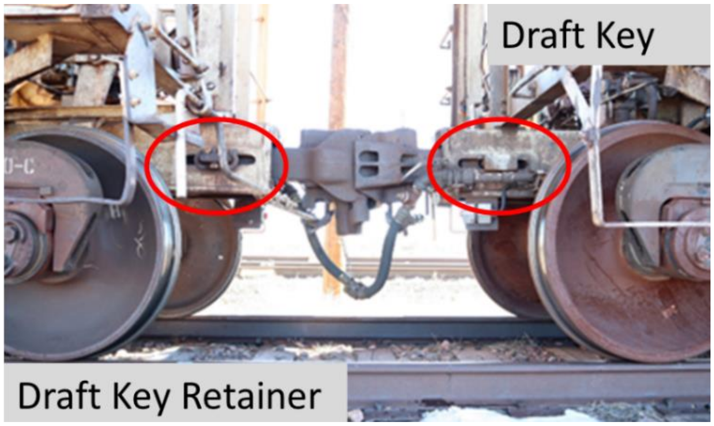

Figure 2. Image area of interest displaying coupler retaining components

TESTING

Testing started with the camera 8 feet away from the track and near the vertical centerline of the coupler. The coupler's centerline was designated as the halfway point from the top and the bottom of the coupler. This placement was not intended to be an optimal position, but rather to discover which items had the potential to block the optical path. Figure 3 shows that the cut lever and brackets are significant obstacles in this view.

Figure 3. Draft key at camera level, camera 34 inches above top of rail

Next, the camera was lowered to look up at the coupler, around the hoses and levers. This view, with the camera tilted upward, should give a better angle to view the underside of the pin holding the draft key in place. Figure 4 shows detail of the cut lever partially blocking the cotter pin in this view. Panning the camera rearward 15 degrees changed the view window slightly, but the cut lever still partially blocks the cotter pin.

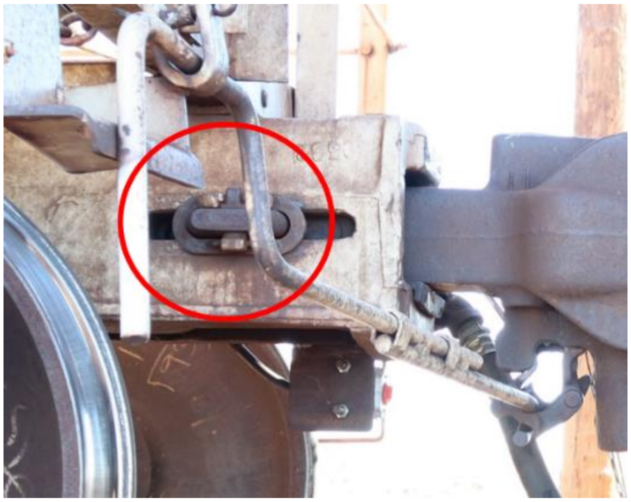

Figure 4. Camera below the coupler and rotated upward

Figure 5 shows detail from this view. Panning of cameras is undesirable when not required because two cameras are required to maintain inspection symmetry for travel in either direction.

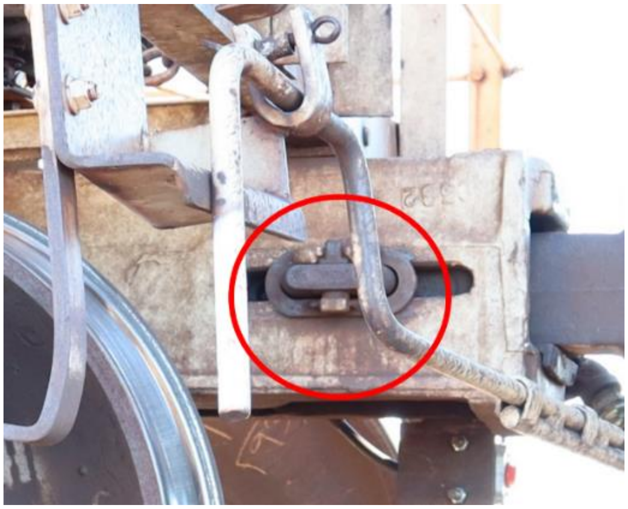

Figure 5. Camera below the coupler and rotated 15 degrees rearward

The next step was raising the camera, moving it higher than the coupler. As the camera was raised, the view improved; however, the bottom of the draft key becomes obscured by the key itself if the camera is raised too high. With the cotter pin on the bottom, it could be hidden by the draft key. Figure 6 shows detail of the view with the camera about 52 inches above top of rail and angled down 10 degrees.

The camera was moved 2 feet longitudinally along the car body in one direction and 2 feet in the other direction. This placement of the camera simulates the car moving through the camera's field of view. Photos taken when the coupling is centered in the image provided the best overall view of both draft keys from a single camera. Panning the camera 15 degrees with a 2-foot offset also provides a superior view, but at the expense of an added camera.

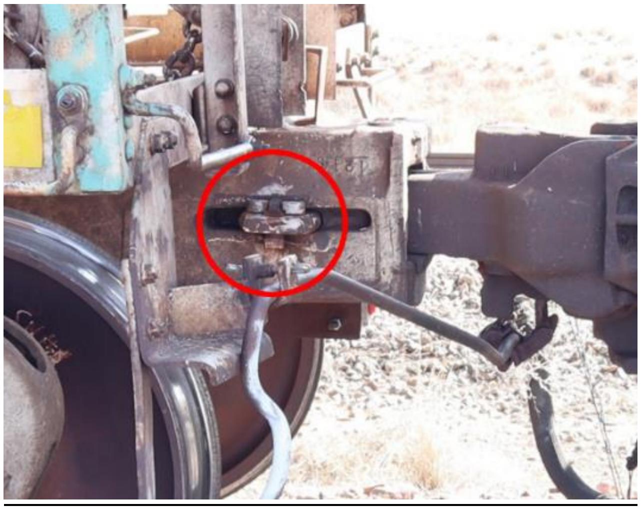

Figure 6. Camera 52 inches above top of rail, angled 10 degrees downward

Other Car Types

Four open coal gondolas cars and one boxcar were studied with conventional draft gear. Similar photos were taken on other car types at the Transportation Technology Center, Pueblo, CO, including tank cars, flatcars, and autoracks with cushion draft gear. Figure 7 shows the detail of the draft key on a cushion-equipped tank car.

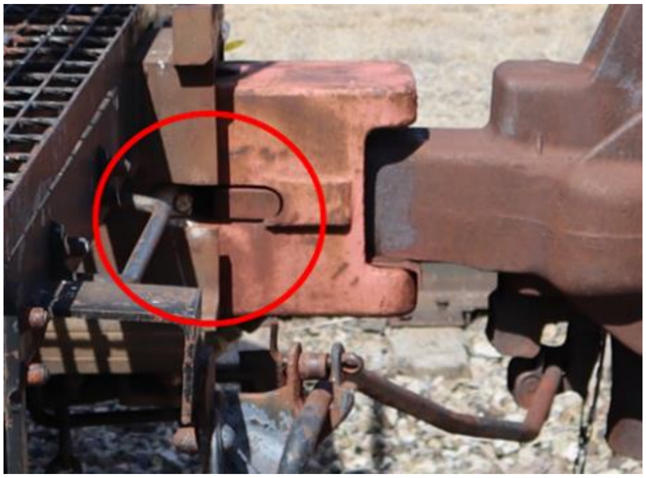

Figure 7. Camera view elevated 52-inches on a cushion-equipped tank car

The draft key is visible in this figure with no obstructions, but the draft system on this end of the car is extended. On the other end of the same car, with the draft system in the buff position, the draft key is obscured by the striker. Figure 8 shows detail of this condition. Train handling at the inspection site must be controlled to assure draft force.

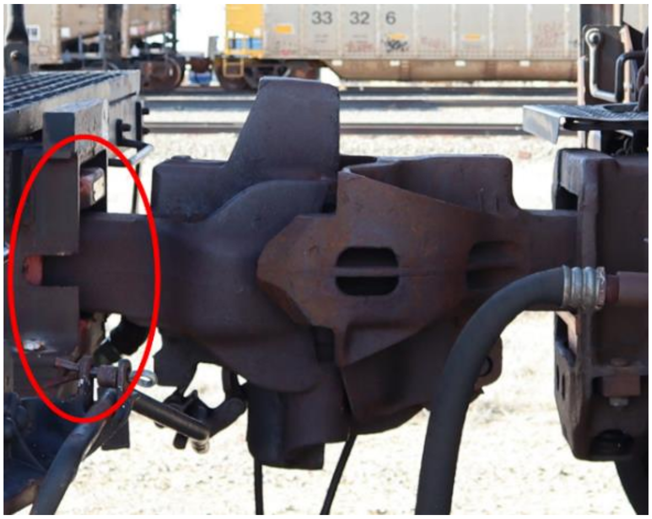

Figure 8. Draft key is obscured when draft system is in the buff position

Acceptability Criteria

All the photos were evaluated on clarity of the area being inspected, such as the coupler section of the railcar. Photos that showed hardware blocking, or partially blocking, the view of the cotter pin were deemed unacceptable for component evaluation. Photos that had unobstructed view were advanced for a more detailed appraisal. Photos were accepted in this stage based on how much of the area was visible and the ease of identifying key components. Lens type and camera distance are recorded for every photo. Lighting and shadowing were not explicitly addressed; only line-of-site visibility.

RESULTS

The study, though focused on cars with draft key retainers and cotter pins, included other types of couplers. The results from the camera being positioned below the coupler center line showed that cut levers, ladders, hoses, and some parts of the car frame often obscure the coupler retention components. Camera positions at the coupler's center line showed similar issues. Cut levers designed to attach below the car frame were less likely to block the coupler in the photos. When the camera was positioned above the coupler's centerline and angled downward, the optical path was more open. However, if the height was increased too much, the bottom of the pin holding the draft key retainer could be hidden from the camera. The best overall position was found to be 52 inches above top of rail, angled down 10 degrees, and centered on the coupling. A pair of cameras in similar position but rotated 15 degrees fore and aft may improve the view on some car types, but at the cost of requiring two cameras per side.

CONCLUSIONS

It may not be possible to image the cotter pin on the coupler retainer for all car types with a single camera. A camera position 52 inches above top of rail and angled downward 10 degrees provides the best single camera view of the coupler retainer on coal gondolas. Two cameras, of similar elevation and tilt angle but panned 15 degrees fore and aft provide an excellent view of each car individually. To avoid levers, air hoses and hardware attached to the car frame, it is recommended that a camera be placed above the centerline of the coupler being inspected, with no rotation and with a 5- to 10-degree downward tilt. Distances of 8 to 12 feet were found to be acceptable with the latter giving a large field of vision. Larger field of vision with high resolution cameras makes more components visible for inspection.

FUTURE WORK

TTCI will continue the camera placement study with emphasis on other components as directed by the TDTI TAG.

For comments or questions about this publication, contact Matt_Witte@aar.com