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Produced for: Marine Systems Engineering Officer, HMCS PRESERVER.

Scientific Letter

Inspection of three forged wire rope clips from the port 15 tonne crane aboard HMCS PRESERVER

Background

DRDC Atlantic Research Centre / Dockyard Laboratory Atlantic (DLA) was requested by HMCS PRESERVER to conduct an inspection on three forged wire rope clips involved in a failure of the port crane [Ref. A]. The rope clips were model G-450 Red-U-Bolts manufactured by The Crosby Group under the trade name Crosby® Clips. On April 22, 2014, the crane's cables were being lubricated as part of the routine maintenance procedure and the tip of the boom was raised a few feet above its cradle. The ends of the cables on the crane are terminated by looping over a structural member, folding the cable back onto itself and securing the end with wire rope clips, as shown in **Figure 1**. The end of the cable at the base of the crane pulled through the wire rope clips, causing the boom to drop onto the cradle. Three of the four wire rope clips were recovered and sent to DLA for examination and to determine if there was any evidence that the clips contributed to the failure (**Figure 2**). A pristine forged wire rope clip, still in its original packaging, was supplied to DLA to provide a baseline for comparison.

The Crosby Group provides information on how the wire rope clips should be installed, including the number of clips that should be used, and a torque specification for installation [Ref B]. For proper installation, it is also recommended that the U-bolt side of the clip mate with the cut end of the cable. It was not known how long the clips had been in service, or how long it had been since the torque had been applied/checked, as checking the torque on the nuts is not part of the crane maintenance procedure. The crane, which is rated to 15 tonnes, was proof tested to 30 tonnes in August 2013.



Figure 1: Schematic illustration of how the Crosby® clips fasten the ends of the crane cable.

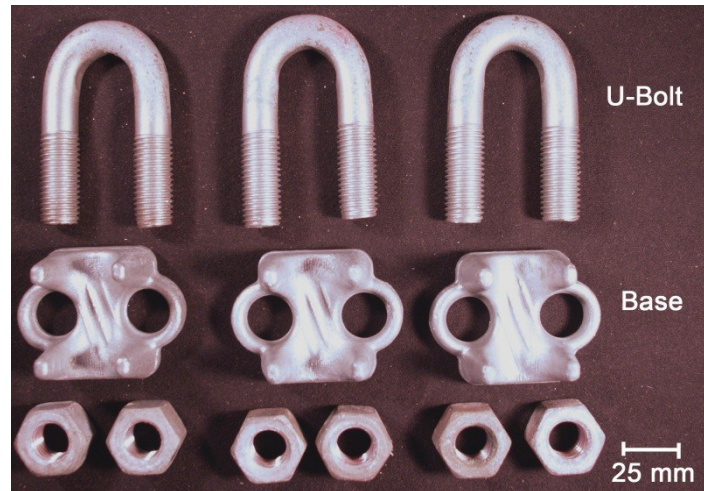


Figure 2: Forged wire rope clips provided to DRDC Atlantic Research Centre for inspection (after cleaning).

Statement of Results

Visual Inspection: The clamps from the failure were compared to the pristine clamp. The inspection showed that the clamps did not undergo any bulk plastic deformation during the failure. The threads on the U-bolt were measured using Vernier calipers and did not show any signs of bulk stretching, which would have indicated plastic deformation of the clamp.

Wear was visible in the U-bolt and base of all three clamps, as shown in **Figure 3**. The lack of corrosion on the worn areas indicated that the damage occurred recently. The wear surfaces were consistent with what would be expected to occur when the cable pulled through the clamps.

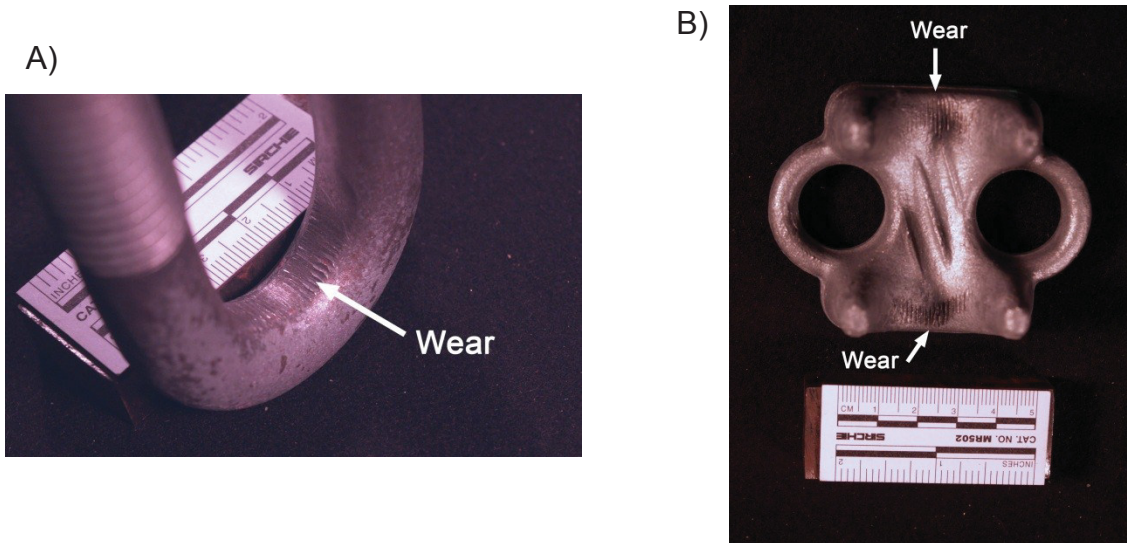


Figure 3: Examples of wear on the A) the U-bolt and B) the base of the forged wire rope clamps.

An *in-situ* visual inspection was conducted on the section of the cable involved with the failure. Certain features on the cable, such as broken strands or wear, could indicate the cause of the failure [Ref C]. The inspection was conducted to see if there were any signs of corrosion, wear, broken strands or strand protrusions that would indicate the cause of the failure. The cable appeared to be in good shape: No strands were broken or protruded; wear and corrosion were minimal. **Figure 4** shows section of the cable with the most corrosion. It can be seen that the corrosion is minimal, and has not caused any of the exterior strands to fracture.



Figure 4: Example of mild corrosion on the cable.

It is possible that repeated loadings on the clips could have caused the initiation and propagation of cracks in the U-bolt, which would have decreased the clamping force on the cables. The Non-Destructive Investigation shop at Fleet Maintenance Facility Cape Scott conducted magnetic particle inspection on the clamps to see if any cracks were present [Ref D], but no cracks were found.

Conclusions

DLA could not find any evidence that the forged wire rope clips were damaged or not functioning properly. There was no discernable evidence of plastic deformation or cracking. Visual inspection of the cable did not show any evidence of damage resulting from misuse or degradation that could be responsible for the failure. As the torque on the clamps is not tested on a regular basis, it is possible that vibrations from the ship caused the nuts to slack off, decreasing the clamping force and resulting in the failure.

Recommendations:

It is recommended that all of the forged wire rope clips in the crane assembly be inspected, to confirm that the U-bolt side of the clips are on the cut-end of the crane and the torque on the nuts is correct. Periodically testing the nuts to ensure the torque is correct could prevent similar failures in the future.

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