Helicopter Rappel Descent Device Evaluation Report: Number 2

Tim Lynch
Project Leader
Missoula Technology & Development Center
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Introduction

In 2008, the Missoula Technology and Development Center (MTDC) began a project to investigate improved rappel ropes and descent systems for the U.S. Department of Agriculture Forest Service's helicopter rappel program. This report highlights the latest project activities and findings. A DVD with video of the recent HR-1 descent device evaluation is available from MTDC on request.

The "Helicopter Rappel Descent Device Evaluation Report: Number 1" was published in May 2008. That report described the first phase of this project, including the findings of a rappel workshop that evaluated two commercially produced rappel descent devices. A DVD with video of that workshop also is available through MTDC.

2008 Sandia Workshop

In April 2008, a group of helicopter rappel spotters and aviation/equipment specialists met at the Sandia Helibase in New Mexico to evaluate equipment and ropes for a new helicopter rappel descent system. The two descent devices evaluated during the workshop, the Petzl ID and SMC Spider *(figure 1)*, were selected for rappel testing based on favorable initial evaluations of both devices.

Figure 1: Petzl ID and SMC Spider

Workshop participants performed many ground simulations and helicopter mockups, and over 100 tower rappels. After reviewing the video and findings of the workshop, the project leader, project sponsor, and participating spotters agreed that neither device was a viable replacement for the Descent Control Sky Genie system currently used by the rappel program.

Project Course Adjustment: Designing a New Descent System

Following the April 2008 Sandia workshop, a small selection of other commercially available descent devices were examined for use in helicopter rappelling. None of these devices were considered for additional testing because they did not meet the Forest Service helicopter rappel program's operational requirements.

With no other promising prospects on the horizon, the project leader proposed that MTDC personnel work with engineers from SMC (Seattle Manufacturing Corp.) to design and develop a new descent device specifically for helicopter rappelling. The project sponsor granted permission for a mid-project course adjustment.

In May 2008, MTDC employees began consulting with SMC's design engineers about the design of a new descent device. The initial design that emerged was superficially similar to the SMC Spider, but featured some significant differences.

A nonworking model was used to develop specifications for individual aluminum components. The first prototype devices featured slight differences between the cam, main frame, and cam pivot geometry. Several variations were tried, tests performed, adjustments made, and a fully functioning prototype was ready in the summer of 2009 *(figure 2)*.

Figure 2: HR-1 descent device

The prototype descent devices were tested with MTDC's Instron 3382 test machine *(figure 3)*. Prototype devices exceeded minimum strength requirements from the National Fire Protection Association 1983 Standard for Life Safety Ropes and Equipment. Among other tests, prototype devices were subjected to static pulls of 4,000 pounds of force, nearly 700 pounds higher than the maximum level required to meet the NFPA 1983 standard for "light" use descent devices.

Figure 3: HR-1 static pull test

To ensure uniformity during tests of the new device, a 12.5 millimeter low-stretch NFPA 1983-compliant rope manufactured by Bluewater Ropes was used throughout the development and testing process.

Additional minor modifications were made to the device's design after the initial rappel function tests in September 2009. Over the winter of 2009-2010, 10 working models of the device were constructed by MTDC for a formal rappel evaluation. This version was named the HR-1 to distinguish it from previous iterations and from other descent devices.

2010 Pacoima Workshop

In March 2010, a group of Forest Service helicopter rappel spotters and aviation/ equipment specialists met at the Los Angeles County Fire Department's Barton Heliport facility in Pacoima, California to conduct rappel evaluations of the HR-1 descent device.

During initial ground training, all of the spotters quickly learned to rig and operate the device. The rappel equipment, procedures, and hand signals used during this workshop were identical to those now used by Forest Service rappellers except for differences related to the HR-1 descent devices, kernmantle ropes, and autolocking carabiners. An operator's guide with inspection criteria and instructions for using the HR-1, ropes, and carabiners was used during training (appendix A). Spotters alternated between performing spotting duties and rappelling, so each participant was able to accomplish roughly the same number of tower spots and rappels during the workshop.

All spotters experienced some degree of hesitancy and lack of smooth braking technique on their first rappels from the rappel tower/simulator *(figure 4)*. After several rappels, each spotter became progressively more proficient and confident, leading to quicker rappels and improved technique.

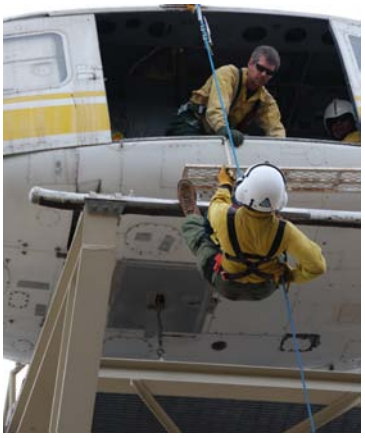

Figure 4: rappeller exiting the simulator

Overall, the HR-1 functioned largely as expected. By the end of the third day of rappelling with the HR-1, all spotters demonstrated a high degree of confidence and proficiency with the device. Workshop participants experienced no unexpected incidents or hard landings.

During the workshop, 237 total rappels were performed with the HR-1 without any significant safety issues. All rappel information and comments by each rappeller were recorded in a logbook (appendix B).

Key findings from the HR-1 evaluation:

1. The HR-1 functioned as expected in slow and regular speed modes. Braking in slow mode was not as smooth and was more "touchy" than braking in regular speed mode, which was anticipated.

2. Rappellers needed practice to consistently find the control lever's optimal position for maximum descent speed and smoothness (users of descent devices refer to this as the sweet spot).

3. Friction and rope compression applied by pulling down with the left hand on the HR-1's control lever provides positive, smooth braking and allows the user to come to a quick stop at the end of a rappel *(figure 5)*.

Figure 5: braking with HR-1 control lever

4. Although the rappeller can apply additional friction/braking directly to the free end of the rope running through the user's gloved right hand, the rappeller can come to a complete stop just by pulling down on the HR-1 control lever.

5. Friction between ropes and the HR-1's components generate enough heat to make descent device cams hot to the touch after 40-foot rappels.

6. The HR-1's auto-stop safety feature functions as expected. Releasing the control lever during a rappel causes the user to stop quickly. Rappellers do not need to perform a lockoff or other procedure to maintain a stationary position after stopping.

7. Low-stretch 12.5 millimeter kernmantle ropes absorb very little shock when a rappeller suddenly stops after a normal descent.

8. The values of peak loads for low-stretch kernmantle ropes when a rappeller suddenly stops or rappels at maximum speed into a knot are not known.

9. Multiple HR-1s can be stacked (prerigged) on each rope *(figure 6).* The standard used during the workshop was to stack three devices and deploy three rappellers per simulation.

Figure 6: stacked HR-1s on rope

10. The HR-1 is simple to rig and de-rig *(figure 7)*. It is practically impossible to misrig the device in a manner that could harm the user. Tests of deliberately misrigged devices showed that the HR-1's design would not permit a hazardous rate of descent even if it was rigged incorrectly.

Figure 7: rigging the HR-1

11. The HR-1 descent device works well with the HR-2 rappel harness, belly deployment (BD) Bag, and Sullivan rappel gloves now used by Forest Service rappellers.

12. The SMC Triguard carabiner worked well to connect the Maillon Rapide tri-link on the HR-2 rappel harness to the HR-1 descent device *(figure 8)*.

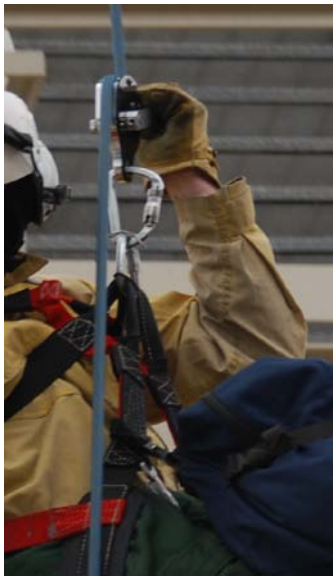

Figure 8: HR-2 rappel harness/HR-1 descent device interface

13. The SMC Triguard carabiner works well to connect rope terminations to anchor attachment points.

14. The Raptor safety knife now used by Forest Service rappellers easily cuts the 12.5 millimeter Bluewater kernmantle rope used with the HR-1.

15. At the end of the workshop, the four rappel ropes showed virtually no significant wear or damage after repeated rappels with the HR-1 (50+ rappels on each rope). Aluminum oxide was deposited on the ropes from the HR-1 descent device, turning the rope's external sheath fibers a grayish color.

16. The durability of the HR-1 descent device appears to be very good. Inspections of the devices after the workshop showed very little visible or measurable wear on the concave contact surfaces of the cams and mainframes.

17. Emergency reentries from the skid and standard emergency tie-off procedures work well with the HR-1 descent device. Rappellers can complete emergency tie-offs with this system significantly faster than they can with the Sky Genie system now in use.

18. A number of HR-1 rappels were performed with 18 pounds of weight attached to the bottom of the rope to simulate the weight of a 300-foot rope. Using a rope feeding technique similar to that used with the Sky Genie system, even the lightest rappellers in the evaluation group were able to exit the simulator skid and begin descending the rope.

19. The more the rope weighed, the harder it was for a rappeller using the HR-1 descent device to rotate over the skid and begin descending. With a light weight attached to the bottom of the rope or when no weight was attached, little or no rope had to be fed to allow the rappeller to rotate off the skid and begin descending. The HR-1 is similar to the Sky Genie in these respects.

20. The HR-1 descent devices had some relatively minor fit and finish issues. The detent pins were too tight on a small number of the devices, and some exhibited a small amount of independent movement between the control levers and shafts.

21. When sand and grit got between the HR-1 cam and backplate contact surfaces, the control lever of some devices felt sticky rather than smooth.

22. The identified HR-1 fit and finish issues can be remedied without affecting the device's performance. MTDC employees are working with engineers from SMC on design improvements to eliminate these problems.

23. The evaluation did not allow us to determine whether it is better to unhook from the HR-1 and leave it attached to the rope at the end of the rappel, or to remove the device from the rope after unhooking.

24. The evaluation did not allow us to determine whether it is better to use an overhand grip or underhand grip to grasp the HR-1 control lever.

25. The evaluation did not allow us to determine whether it is better to have the gate of the attachment carabiner on the HR-2 rappel harness face toward or away from the rappeller.

26. Double-sewn rope end terminations were used because other options significantly reduce rope strength and/or add weight.

27. The plastic shrink-wrap used to protect sewn terminations sometimes slipped out of position.

28. Snub straps now in use have not been tested for compatibility with sewn termination kernmantle ropes.

29. The spotter task group feels there is merit to increasing the standard rappel rope length from 250 feet to 300 feet.

30. Bluewater 12.5 millimeter kernmantle rope with double sewn terminations weighs about 22 lbs for 300 feet.

31. Bluewater 12.5 millimeter kernmantle rope with double sewn terminations on both ends costs about $300 for 300 feet.

Summary

While the March 2010 evaluation of the HR-1 descent device could not be considered an unqualified success, the evaluation clearly showed that the device works well enough that additional refinements are worth pursuing.

During the evaluation, 237 rappels were performed without any hard landings or braking problems, which shows that the HR-1 descent device functions as intended. Once rappellers became comfortable with increased speed, they were able to come to a smooth, quick stop by applying down-force on the control lever.

The HR-1 descent devices and 12.5 millimeter Bluewater kernmantle ropes showed virtually no significant wear after many 40-foot rappels. The lack of measurable wear on the HR-1's polished aluminum contact surfaces shows that the device's braking components appear to be "rope friendly" and that the device is durable.

Future Plans

During the evaluation's closeout, participants suggested the following improvements to the HR-1 descent device:

- Eliminate independent movement between the control lever and shaft
- Alter the detent pin so it is easier to release
- Round off the upper mainframe to improve feeding and performance with weighted ropes
- Increase the tolerances between the cam/backplate and the pylon/faceplate
- Install stainless steel washers between the cam/backplate and the control lever/backplate

After reviewing the evaluation's findings, the project leader and project sponsor agreed that the next phase of this project should focus on correcting the deficiencies identified above. Employees from MTDC and SMC are currently redesigning the HR-1 to incorporate these changes.

Ten new prototypes will be prepared for additional rappel testing. MTDC will build some devices with cams constructed from stainless steel to compare the braking performance, heat dissipation characteristics, and long-term wear resistance of steel cams with aluminum cams.

Assuming that the 10 new prototypes pass preliminary tests, a third rappel workshop will be convened for the spotter task group to evaluate the devices' performance. The tentative plan for the third evaluation is to reacquaint spotters with the descent device by rappelling from a tower and then progress to rappelling from helicopters.

Helicopter rappel tests from a Bell 205 or 212 will begin at 50 feet above ground level (AGL) and gradually increase in 50-foot increments to 300 feet AGL. This phase will reveal how well the new prototype descent devices resist wear and dissipate heat on full-length rappels and further test overall functional performance.

Helicopter rappel tests at 300 feet AGL are also necessary to determine whether the exterior sheath fibers of kernmantle ropes are susceptible to heat damage from prolonged contact with descent device components on long rappels. A video and report on the helicopter rappel workshop will be produced by the project leader.

In the meantime, the project leader will conduct peak load tests from a fixed rappel tower using the HR-1 and companion 12.5 millimeter low-stretch Bluewater rope. Although these tests will not precisely duplicate the forces that would be experienced by rappelling from a hovering helicopter, they will give engineers useful data on the peak loads being imparted to anchor systems and personnel when rappellers make a sudden stop.

Acknowledgments

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The use of the Barton rappel tower, and the assistance and hospitality of Chief Anthony Marrone and Captain Mike Layhee of the Los Angeles County Fire Department, were greatly appreciated.