IMPROVED SEALANTS FOR M-44 CYANIDE CAPSULES

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ABSTRACT: The M-44 sodium cyanide ejector is one of the most important tools used by the Animal Damage Control (ADC) program to protect livestock from coyotes. Unacceptable performance of M-44 cyanide capsules due to inadequate seals stimulated research to develop a better capsule sealant. Comparative tests of crude beeswax, Scheel SC-100 wax, and other materials revealed that capsules sealed with SC-100 were most resistant to deterioration in adverse environments. Based on these results, SC-100 wax was selected as the sealant of choice. Beginning in April 1989, all M-44 capsules made for ADC program use have been sealed with SC-100 wax. Since that date, the average number of capsules sold annually for ADC use is 15% lower than it was before 1989 even though the numbers of coyotes taken by M-44s each year has nearly doubled. The improved sealant appears to have increased the service life and effectiveness of M-44 cyanide capsules.

KEY WORDS: predacides, canids, coyote, control methods, M-44, sodium cyanide.

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INTRODUCTION

Sodium cyanide (NaCN) ejectors have been used to kill coyotes and other wild canids for more than 50 years. The Humane Coyote Getter® was used from about 1940 through the 1960s, followed by the safer, spring-activated M-44 cyanide ejector from 1970 to 1972 and again from 1975 to date. During most of these 55 years, the effectiveness of cyanide ejector devices has been compromised by several chronic problems including poor cartridge or capsule seals.

When set in the field, the M-44 ejector device holds a cyanide capsule that contains approximately 1 gram of a powdered or granular NaCN mixture. When a target canid activates the device by biting and pulling it, NaCN mixture is expelled rapidly from the capsule into the mouth of the animal. The dry powder reacts with moisture to produce hydrogen cyanide gas which kills the animal quickly; the time to death for coyotes is 90 to 150 seconds (Connolly et al. 1986).

All NaCN ejectors and capsules used by the ADC program are made at the Pocatello Supply Depot (PSD) in Pocatello, Idaho and are shipped to ADC offices where they are stored until needed in the field. With this supply system, the capsules typically are not used in M-44 ejectors until they are several months old. Once an M-44 is set, it may remain in place for many weeks or months before being pulled by a target canid. Thus, the capsule seal must maintain its integrity through many months of shipment, storage, and field exposure.

If the seal is defective or is damaged at any time during these many months, moisture will enter the capsule and react with the NaCN mixture to form a solid "cake." In time, the caked mixture will degrade into a discolored liquid. Caked or liquified NaCN mixtures are relatively unreactive and, when ejected, usually will not kill the target canid. Thus, an effective capsule seal is essential to the efficacy of this device.

ADC specialists' reports of poor M-44 performance stimulated research on M-44 improvement beginning in 1981. A team of specialists from ADC operations, research, and PSD identified and solved several of the problems that were responsible for poor M-44 performance. The first experiment revealed that inadequate capsule seals were a major problem (Connolly and Simmons 1984). Subsequent study showed that the addition of beeswax on top of 3M #4693 adhesive (the standard sealant used before 1983) improved capsules significantly (Connolly and Simmons 1983).

Beginning in August 1983, all M-44 capsules made by PSD were finished with a hot beeswax seal. Melted beeswax was applied by gravity flow from a heated container in which wax temperatures varied between 133 to 166°C with an average of 154°C (DWRC, unpublished data, October 6, 1987).

Subsequent experience showed that hot beeswax, though superior to the 3M adhesive, was not a complete solution. Long-term weathering studies demonstrated that capsule seals were more likely to deteriorate during shipment and storage than in actual field use. Beeswax seals were found to be vulnerable to damage if the capsules were exposed to ambient temperatures over 140°F, a level often reached in closed tool boxes on warm, sunny days in the western U.S.

Late in 1986, PSD changed the capsule sealant from crude beeswax to a refined, white beeswax. At the time, there was no basis to think that such a change would affect capsule quality. However, increased numbers of field complaints stimulated an investigation in 1987. Ultimately, it was found that white wax seals were inferior to crude beeswax seals, possibly because the white wax melted at a lower temperature. This experience resulted in a new research initiative aimed at identifying a better sealant for M-44 cyanide capsules.

Screening of candidate sealants, followed by rigorous evaluation of the best candidates, resulted in the identification of two materials that were superior to beeswax. One of these—SC-100 (Scheel wax 100, Scheel Corporation, Brooklyn, NY)—was recommended for immediate adoption. All M-44 cyanide capsules produced since March 1989 have been sealed with this product. This paper summarizes the research effort that resulted in the identification of Scheel SC-100 wax as a superior

M-44 capsule sealant and reviews subsequent ADC program experience with the improved M-44 capsules.

PROCEDURES

Criteria For An Effective Seal

The first step in evaluating M-44 capsule sealants was to develop written criteria for an acceptable seal. An acceptable sealant must:

- Adhere to the polyethylene (high DIN, Marlex 6050, Phillips, or equivalent) from which M-44 capsules are made.
- Produce a water-tight seal lasting a minimum of one year from date of application, under all environments encountered in manufacture, shipment, storage, and use of M-44 cyanide capsules.
- Release instantly or not hamper ejection when the M-44 is pulled by a target animal.
- Be odor free, or the odor must neither repel target animals nor attract nontarget animals or insects.
- Be affordable, readily available, safe to workers, easy to apply, and fast drying (within 24 hours).

Identification of Candidate Sealants

Samples of sealants to meet the criteria stated above were solicited from commercial manufacturers of sealing waxes. In addition, materials previously identified as potential sealants were considered. In all, nine products were evaluated including crude beeswax, refined white beeswax, and seven new materials. Six products soon were dropped based on preliminary testing and are not further discussed in this paper. The candidate sealants retained for rigorous evaluation were:

- Crude beeswax (BW) procured from local sources in the vicinity of Pocatello, Idaho.
- Daige Speedcote, Type BB9, pressure sensitive adhesive wax (Daige products, Albertson, NY).
- Scheel SC-100 microcrystalline, petroleum hydrocarbon wax (Scheel Corp., Brooklyn, NY).

Evaluation of Candidate Sealants

The relative effectiveness of candidate sealants was evaluated by comparing the resistance of capsules sealed with each material to a series of environmental challenges. Following preliminary trials that are not detailed in this report, 600 capsules were filled with NaCN mixture on the PSD production line for a definitive evaluation. Two hundred capsules were sealed with each of the three materials listed above—Crude BW, Daige, and SC-100. In all other respects they were standard M-44 cyanide capsules as routinely produced for use by ADC personnel.

The 600 capsules were subjected to five rounds of increasingly severe environmental challenges over a six-week period during November-December 1988 at a DWRC research station in southern Idaho. Treatments proceeded as follows:

Round 1: Capsules (200 per sealant) were placed in a laboratory oven at 54°C for 5 hr, followed by 26 hr in a freezer at -17 to -20°C, followed by 3 hr in a water bath beginning at 40°C and cooling to 27°C. After air drying for 2 hr at 14.5°C, the capsules again went into the oven at 38°C for 2.5 hr. After overnight cooling to ambient temperature, 25 capsules per sealant were examined.

Round 2: Capsules (175 per sealant) were placed in the oven at 52°C for 5 hr, followed by 18 hr in freezer at -15°C, followed by 3.5 hr in water bath beginning at 41°C and cooling to 26°C. After draining at ambient temperature, they again went into the oven for 23 hr at 40°C. During this treatment, open pans of water also were kept in the oven to maintain high humidity. After three days at ambient temperature (10-20°C), 25 capsules per sealant were examined.

Round 3: Capsules (150 per sealant) were placed in the oven at 55°C for 6 hr, followed by 1 hr in water bath at 13-15°C. The capsules were then placed outside for five days in late November weather that consisted of rain, snow, and cold temperatures. Fifty capsules per sealant were examined.

Round 4: Capsules (100 per sealant) remained in the outdoor environment for 15 days (until December 14, 1988). They were covered by ice or snow during most of this time. After 24 hr indoors to dry at ambient temperature (22°C), 25 capsules per sealant were examined.

Round 5: Capsules (75 per sealant) were placed in the oven at 62-64°C, followed by 3 days in an outdoor water bath during which time they became frozen within a solid block of ice. The ice block then was brought indoors to thaw 24 hr at ambient temperature (21°C), after which the capsules were spread to air dry. All capsules (75 per sealant) were then examined. The study was terminated at this time because all of the crude BW seals had failed.

The capsules that were selected for examination after each round were first inspected visually and the apparent condition of each top seal was noted. Each seal was recorded as condition 1 (intact; apparently like new), condition 2 (slight deterioration but seal appeared good), or condition 3 (deteriorated and no longer effective). Each capsule then was opened so that the consistency of the NaCN mixture could be assessed as condition 1 (normal dry powder), condition 2 (slight caking), condition 3 (more caking), condition 4 (harder caking), condition 5 (entire capsule contents solidified), condition 6 (cyanide mixture damp or liquid), or condition 7 (contents missing).

RESULTS

The results of individual capsule examinations were summarized into percentage scores for each group of capsules (Table 1). As expected, all three sealants fared well through round 1 with few adverse effects seen. By the end of round 2, some deterioration was noted for the Daige and crude BW seals. The crude BW seals deteriorated further in round 3. By the end of round 5, all the crude BW seals appeared to have failed and only 15 percent of these capsules retained the cyanide contents in normal, dry condition. Capsules sealed with Daige and SC-100 fared much better. SC-100 appeared much superior to Daige in round 4 but slightly inferior in round 5.

DISCUSSION

This research identified both Daige and SC-100 waxes as superior M-44 capsule sealants (Table 1). It is believed the main reason for the superiority of Daige and SC-100 was their higher melting temperature; Daige and SC-100 melt at 170 to 180°F, compared to 140 to 150°F for beeswax. In addition, beeswax was found to shrink as it cooled, whereas Daige and SC-100 did not shrink.

The results of this study were submitted to the PSD manager in March 1989 with a recommendation that PSD immediately switch from crude BW to another sealant for M-44 capsules. Either SC-100 or Daige would have been superior to crude BW, but SC-100 was recommended as the sealant of choice because it scored higher than Daige in most comparisons. In addition, SC-100 had other, minor advantages:

- SC-100 produced less capsule flare (expansion of capsule mouth, a phenomenon associated with all hot wax seals on polyethylene capsules).
- SC-100 was had less odor, so was felt less likely than Daige to be detected by target canids or to repel them.
- Daige remained tacky when cool whereas SC-100 did not, indicating that SC-100 would be less likely to attract dirt under field conditions.
- SC-100 cost $1.25 per pound, compared to $6.80 per pound for Daige (September 1987 prices).

As noted previously, all M-44 cyanide capsules produced at PSD since March 1989 have been sealed with SC-100 wax. Experience since that date has confirmed expectations that this change would improve capsule quality; field reports of problems with M-44 capsules have decreased significantly. Nevertheless, occasional reports of defective M-44 capsules continue to be received, indicating that the SC-100 seal has not solved all capsule quality problems. Considering the conditions under which M-44 capsules are used, it may be unrealistic to expect a perfect sealant.

Trends in ADC program M-44 use were examined relative to the timing of research on M-44 improvement. ADC use of M-44s was near an all-time low in 1981 when the original studies began. This was reflected in the relatively low numbers of coyotes, approximately 6,000 to 7,000 per year, taken annually with M-44s by ADC personnel in FY 1980-82 (Table 2). The coyote take by M-44s increased through the 1980s as improvements to the capsules and other M-44 components were implemented. From a low point in about 1980-82, the ADC coyote take by M-44s nearly doubled by 1989. The take has nearly doubled again since 1989 when the improved M-44 capsule sealant was adopted.

Of particular interest is the fact that the increased coyote take by M-44s since 1989 was achieved without a corresponding increase in the number of M-44 capsules produced (Table 2). The average number of capsules sold by PSD annually since 1989 was approximately 89,000, some 15% fewer than the annual average of about 104,300 capsules sold during 1983-88. Remarkably, this reduction occurred during the same years (FY 1990-95) in which the average annual ADC coyote take by M-44s increased to 23,444, almost double the annual average of 11,934 coyotes taken during FY 1983-88. Thus, the ADC program used an average of about 8.7 capsules per coyote taken by M-44 during 1983-88, but only 3.8 capsules per coyote taken during 1990-95. It appears that the improved capsules in use since 1989 are lasting longer and performing better.

Assuming that ADC's annual coyote take by M-44s during 1990-95 would have been the same with or without the capsule improvements that were implemented in 1989 and that, without those improvements, the number of capsules per coyote would not have changed from 1983-88 to 1990-95, the economic value of the improved capsule seal can be estimated as (cost per capsule) X (capsules saved per coyote taken) X (number of coyotes taken). The current PSD price is $37.35 per box of 50 capsules, or about $0.75 each. On this basis, the improved capsule seal has produced average savings of approximately $86,000 each year since 1989.

Important nonmonetary benefits of the improved capsule seal include increased confidence among ADC specialists and ADC clients that the M-44 will perform as intended, as well as fewer target canids escaping after they activate an M-44 device.

Table 1. Effects of cumulative environmental challenges on the integrity of M-44 cyanide capsules sealed with Daige, SC-100, and crude beeswax.

		Capsules With					
		Intact Top Seals			Normal NaCN Contents		
Treatment Round	Number Examined	Daige (%)	SC-100 (%)	Crude BW (%)	Daige (%)	SC-100 (%)	Crude BW (%)
1	25	100	100	100	100	100	100
2	25	96	100	92	88	100	76
3	50	92	94	58	66	84	60
4	25	96	100	76	12	76	64
5	75	64	63	0	79	64	15

Table 2. Annual ADC program sales of M-44 cyanide capsules and numbers of coyotes taken by M-44 cyanide ejectors, 1980-1995.

Year	Capsules Sold[1] (Calendar Year)	Coyotes Taken (Fiscal Year)
1980	65,766	6,282
1981	59,725	6,123
1982	73,459	6,874
1983	113,250	9,680
1984	115,650	11,577
1985	94,450	11,896
1986	142,450	12,957
1987	71,050	11,826
1988	89,050	13,669
1989	101,050	15,610
1990	100,600	20,872
1991	93,750	24,762
1992	92,149	25,239
1993	84,259	23,183
1994	86,150	23,217
1995	77,236	23,390[2]

[1]Includes all capsules sold from Pocatello Supply Depot for ADC program use under EPA Registration Numbers 6704-75 and 56228-15.
[2]Preliminary count subject to correction.

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