

Technology Development Center

## **MARKET REPORT**

# **RESULTS OF FOCUS GROUPS AND IN-DEPTH INTERVIEWS ON COMMERCIALIZATION OF ROAD MAINTENANCE TECHNOLOGY CRACK SEALING DEVICES**

**Prepared by Technology Development Center  
January 7, 1994**

## INTRODUCTION

During the weeks of December 6 and December 13, Technology Development Center (TDC) engaged representatives of California cities and counties, the Nebraska State Department of Roads, and two private, for-profit crack sealing contractors in Orange County, Associated Industries, Inc. and Rubberized Crack Filler/Sealant, Inc. in focus group and in-depth interview market research.

The three new concepts in the attached appendix were evaluated in order to obtain an exhaustive set of inferences regarding their potential marketability, and to guide further design work.

Sources from the list of attendees are seldom quoted since they were promised anonymity to insure unbiased response styles.

The results of the research are qualitative, as focus groups are qualitative rather than quantitative instruments.

The attendees and results were as follows:

### FOCUS GROUPS

#### *NEBRASKA STATE DEPARTMENT OF ROADS*

Attending:

1. Francisco Arroyo, Crew Chief
2. Gerald Zieg, Auto/Diesel Mechanic
3. Brian L. Mariska, Equipment Engineer
4. Rollie Heedum, Maintenance Manager
5. Jerry Yeager, Senior Maintenance
6. Dan Warnkee, Highway Maintenance Crew Chief
7. Ray Beeman, Maintenance Supervisor
8. Donnie R. Laughlin, Senior Maintenance
9. Dalyce Ronnau, Assistant Maintenance Engineer
10. Ervan Ehulich, Highway Fleet Manager

#### *CALIFORNIA CITIES AND COUNTIES*

Attending:

1. George Friedenbach, Street and Storm Drain Supervisor, City of Santa Clara
2. William Floyd, Road Superintendent, County of San Mateo

3. Robert Radcliffe, Equipment/Service Manager, County of San Mateo
4. John A. Simmons, Senior Highway Maintenance Supervisor, County of Sacramento
5. Niles A. McDonald, Supervisor Class II, City/County of San Francisco
6. Joe Rosenlund, Assistant Maintenance Supervisor, City of Vallejo
7. John Wood, Operations Supervisor, City of Concord
8. Frederick H. Foster, Senior Civil Engineer, City of Concord
9. Peter Lepeisto, Highway Maintenance Supervisor, San Joaquin County

## **IN-DEPTH INTERVIEWS**

### *ASSOCIATED INDUSTRIES, INC.*

1. Jim Arriaran, Project Coordinator
2. Richard DeBrwim, Crew Supervisor

### *RUBBERIZED CRACK FILLER/SEALANT, INC.*

1. Jeff Stephan, Vice President

## **GENERAL RESULTS**

### **HIGH PR/LOW MONETARY VALUE IN REMOVING WORKERS FROM THE ROADWAY**

#### Highly desirable to remove a worker from the road

All else equal, agencies would value crack sealing equipment which removes a worker from the roadway and hence reduces exposure to traffic. Furthermore, workers in colder states like Nebraska would also like to get off the road (and in the vehicle) to avoid cold weather. It thus appears this benefit would sway the purchase decision toward ACSM equipment if other factors (efficiency/productivity, etc.) are at least equal relative to current crack sealing methods.

#### But minimal willingness to pay for the extra safety from removing one worker from the road

Though they considered it highly desirable for safety and public relations reasons, the average agency estimated it would be willing to pay either nothing or in the very low thousands to remove one crack sealing worker per crew from the road. This is because 5 or 6 people would still remain on the road in their crack work teams after the one worker

(squeegee operator) was liberated from the crack sealing team and made available for another function.

**Note:** However, safety aside, agencies do place a high value on the wage savings from eliminating one worker from a crack sealing operation.

### Small batches of cracks with distance between them

Many local agencies travel between and seal only small, crack-dense sections of road, stopping (rather than just controlling) traffic each time they work. This fact reportedly limits the safety value of getting one worker off the road and onto a vehicle. However, state agencies which seal cracks on long stretches of road (with a lower level of traffic control) would attribute greater value to reducing their worker traffic exposure by one, as mentioned above.

## **OPERATORS MUST SIT RATHER THAN STAND**

All crack sealers reported that OSHA (Occupational Health & Safety Administration) would require that a worker riding on any moving vehicle (truck or trailer, big or small) be seated and restrained, rather than standing, for the following reasons:

Firstly, a worker standing in a vehicle (truck or trailer) is trapped if/when a motorist enters the work zone. This means high injury potential since the worker cannot move completely out of the way (as when standing on the ground).

A standing worker is not protected by a safety restraint from a secondary collision with the vehicle on which he is standing during an impact.

Standing workers could lose their balance when brakes were applied.

Lastly, agencies insisted that workers would be inclined to jump up and ride on a vehicle for short trips (i.e. around the block or between different batches of cracks) at greater-than-crack-sealing speed. This does not happen now, they reported, because their operations do not call for anybody to be standing in the truck or melter trailer, except just briefly to adjust the equipment. But they were adamant that once a truck or trailer was made with a place for standing, workers (in addition to just the operator) would start taking short trips, regardless of what rules are enacted to the contrary.

## **POSSIBILITY THAT OPERATOR MAY NOT BE ALLOWED (EVEN SEATED) TO RIDE IN A TRAILER**

Assuming seated-restraint of the equipment operator, a truck was unanimously considered marginally safer than a trailer due to size and weight. But there was disagreement about whether OSHA would condone a worker riding in a trailer at all.

California local agencies considered the two options (truck and trailer) to be in the same general tier of safety and foresaw no regulatory problems with a worker seated and restrained in either a truck or a trailer during crack sealing.

Conversely, the Nebraska State Department of Roads predicted a seated-restraint truck scenario would be okay, but unanimously doubted OSHA would condone workers riding on a trailer, restrained or not. They even saw a small chance of a restriction against riding in a truck for crack sealing, since the current Nebraska paint striping operation allows an operator to sit in a truck (not a trailer), but the truck is moving much faster than crack sealing speed and there are two trucks in back of this person (between him and the traffic), rather than just the one attenuator vehicle they use in crack sealing.

## **SAFETY ASIDE, A STRONG PREFERENCE FOR CARRYING MELTER & OTHER SEALING EQUIPMENT ON TRAILER RATHER THAN ON TRUCK**

When asked if they would prefer equipment attached to a trailer or a truck (with the melter in the truck), all crack sealers strongly preferred the trailer option, and most refused to carry a melter (trailer or skid) in a truck for the following reasons:

*Extra sealant*--Currently, agencies pull the melter trailer and carry extra sealant material with the same truck. With the melter in a truck, agencies would need to add another vehicle to their current crack sealing operations to carry extra material, or use a truck large enough to carry the melter and the extra material. Reportedly, such a truck, if available, is valuable in other areas besides crack sealing.

Either of the above options would mean a large investment and much larger depreciation/amortization cost for equipment used in crack sealing than is currently the case (see *financial* below). Furthermore, according to one respondent, as much as four feet more bed length could be necessary to carry the extra material. The amount of extra material

needed in a day depends on productivity, but can be as high as 3,500 lbs for some private contractors, though 1,000 lbs would be more typical for a public agency.

*Financial*--Currently, most public agency crews reportedly use 200 to 300-gallon melters, and many private contractors use the 350 to 400-gallon size because of their greater productivity. This means the truck to carry the melter and extra material would have to be anywhere from four to seven ton size (a 350 gallon melter is 9,000 lbs full, which does not include extra material which would have to be carried as well). Also, as stated above, the trucks would also have to be very long in order to accommodate the material, the melter, and the operator.

The extra cost above using the smaller one or two-ton trucks which are typical in crack sealing currently would reportedly be prohibitive. Half of the California agencies thought they might have trucks large enough for this somewhere in their agencies, as well as equipment to lift a melter in and out of a truck, but said the extra cost could not be justified amidst anything but an extremely large increase in productivity. The Nebraska state department of roads said it did not have any flatbeds large enough to carry a melter, (or a means of lifting the melter in and out)--they would thus have to buy a new, very large truck just for crack sealing, which they could not justify.

*Flexibility*--Agencies will only consider carrying a skid mount melter (without wheels) in a truck. They felt carrying a trailer melter in a truck would be unsafe because the trailer's wheels would be in contact with the bed of the truck. Agencies conceded that it would certainly be possible to develop a method to safely restrain a trailer melter in a truck, but that the sight of workers carrying a trailer in a flatbed truck would be a public relations problem, so they would still only consider using a skid melter.

And with a skid melter, the agencies explained, they would be denied the flexibility of moving to their current crack sealing method on days when it was necessary to employ the large truck outside of crack sealing.

Furthermore, none of the agencies interviewed own any skid mount melters presently, so they would have to be asked to purchase new melters for any crack sealing option where the truck carried a melter. For financial reasons, such a scenario would limit sales mostly to agencies who are ready to retire an existing melter as most crack sealers reported that they currently have to wait until current melters fully amortize before they can buy new ones.

Agencies reported another flexibility constraint. They said that even if they could carry a melter trailer in the back of a truck (to leave the melter trailer free for use for crack sealing on days that the large truck was needed elsewhere), choosing where to mount wands, hydraulics, etc. would be challenging. If the equipment was mounted on the melter in the truck, workers could not reach it from the ground; and if mounted on the truck, it would have to be removed from the truck and remounted on the trailer in order for the trailer to be used separately on a particular day.

*Maneuverability*--With a truck large enough to carry a melter, local agencies foresaw problems with maneuverability relative to the smaller trucks and trailers now used, i.e. turning around in cul-de-sac, etc. This does not seem to be a problem for state level departments of transportation, however, which seal long stretches of mostly straight freeways and highways.

### **UNANIMOUS DESIRE FOR A SHALLOWER, THINNER, FLATTER SEAL**

The agencies interviewed expressed concern about people falling on bikes and rollerblades when they hit seals which protrude too far upwards from the road surface. One agency represented had to revisit worksites and file all of their seals down for rollerbladers after a lawsuit.

### **CRACK-SEALING SEASONS AND VOLUME OF CRACK SEALING PER YEAR**

Local California agencies in the study reported crack sealing seasons of three or four months each, during which one crew per day crack seals. None of these seasons begin earlier than March or end later than October, suggesting this is the general crack sealing season in California. This period of time appears to roughly consistent with CrafcO's recommendation that several sealing materials be used in weather above 40 degrees Fahrenheit, and also appears consistent with the reported advantage in sealing under dry conditions when drying the cracks before sealing is unnecessary. Private contractors reportedly seal during this general season as well, but with a sealing volume driven by demand.

Nebraska State Department of Roads reported a different strategy: They perform crack work from December through early March, deliberately during the cold weather, in order to avoid problems with cars tracking around freshly-applied material.

An anonymous sales manager of a company which supplies crack sealant said that on a national scale, there is no general crack sealing season. Crack sealing is always being performed in many locations in the United States during any time of the year. He knew of no geographic patterns which systematically link earlier or later-in-the-year sealing with particular locations or climates.

## **FINDINGS WHICH APPLY TO ALL THREE CONCEPTS EVALUATED**

### **BENEFITS FROM ACSM TECHNOLOGY FORESEEN BY CRACK SEALERS**

#### Safety

The hose would be restrained with all new concepts, lessening the chance of burn if it breaks and spews sealant; it would lack the freedom of movement to swim around after breaking, as the current hoses can.

Burning oneself when the equipment was functioning properly would also be more difficult, since workers would no longer be handling hot wands.

Since the workers would not be tied up with the equipment, they could extricate themselves from the path of danger if a motorist strayed into the work zone, or if a hose broke. (Under many current agency crack sealing protocols, workers are tied to the wands with slings over their shoulders which traps them in dangerous situations).

Elimination of the squeegee (and perhaps also the wand person's) position on the road again provides a net reduction in worker exposure to traffic.

#### Productivity

Faster sealing would be very valuable to those interviewed, though looking at the concepts they refuse to believe the sealing is faster until they see a demonstration.

Consistent sealing quality and shape means less wasted material.

#### Higher quality seal

This means reduced liability for cracks/bad seals (when bicyclists or rollerbladers fall, etc.), and better seal performance (longer lasting).



### Ease of use/ergonomics

The equipment was seen as having the ability to potentially reduce back strain/injury. The Nebraska State Department of Roads constantly rotates workers when crack sealing because their people can only support the current 80 LB hose/wand assembly for 30 minutes at a time.

## **ISSUES WHICH MAY MITIGATE THE MARKETABILITY ACSM CONCEPTS UNDER EVALUATION**

### Maneuverability/weight

Every crack sealer feared that the inertia of the sealant applicator assemblies would limit the handling and maneuverability relative to the wands currently used.

### Speed of boiling material is the current bottleneck in crack sealing

The speed with which material can be melted for sealing is the bottleneck in the manual crack sealing methods now used. Any improvement in application speed, therefore, will not improve the total sealing speed unless a faster way to melt material is devised. One for-profit crack sealer outruns the speed of their 350 gallon melter, but says CrafcO will soon begin offering a 500 gallon melter which they hope will match their manual application speed.

Most cities and counties interviewed use the smaller 200 or 250 gallon melters. With a 200 gallon pot, the Nebraska State Department of Roads must pause every half hour during crack sealing to allow processing of more material. CrafcO is reportedly working on a system to melt material faster.

### New system not the only way to reduce back injury

A couple of crack sealers contacted use a boom protruding from the back of a melter trailer to support the weight of the hose and wand. This innovation appears to create the benefit of reduced back strain at a lower cost than the concepts under evaluation.

### The squeegee person is already obsolete

This result was not unanimous, but some crack sealers already circumvent the squeegee step with a simple v-shaped metal attachment on

the end of their wands, or with a round attachment they call a "shoe," both of which shape the sealant as applied. Again, this seems like a cheaper way to create one of the key benefits of the concepts under evaluation, namely taking the squeegee operator off of the roadway.

#### Wasted material

Value of the benefit of less wasted material is unclear. Some crack sealers feel they already make efficient use of sealant with their current methods, whereas others concede that they do not.

### **MAJOR CONCERNS ABOUT ALL THREE CONCEPTS EVALUATED**

#### Freezing of sealant

Although the hose can be detached from the sealant applicator for recirculation of sealant (while a crew lunches or rests), crack sealers in Nebraska were concerned about the sealant in the sealant applicator itself being allowed to freeze because it is not recirculating.

### **MINOR CONCERNS**

#### Retrofit of melter trailers

Participants were mildly concerned about having to retrofit their melter trailers to hold new equipment. They say these trailers are not built with much room to spare.

### **CONCERNS ABOUT NEW SEALANT APPLICATOR**

#### Maintenance on brush

Crack workers worry about having to change the brush--they fear frequent "plugging up."

#### One pass sealing doubtful

Crack sealers did not believe that one pass crack sealing would be possible with the new sealant applicator. They said that wider sections of crack invariably allow freshly-applied sealant to settle. This problem is currently addressed by doubling back to seal bad spots during delays to boil more material, or (but preferably not, because of cost) on a future day. Participants did not believe that the sealant applicator will produce

seals that will be immune to settling altogether. As a result, they said that crack work would have to be revisited as often as with the current work, though during a revisit less sealing would have to take place. They say that even if a much smaller percentage of seals settle (due to greater quality of seals with the new sealant applicator), they will still incur about the same cost in their time since any settling at all means a revisit.

#### Perfect appearance of the seals

A concern only to Nebraska was that the new sealant applicator would make such a neat patch (straight edges, consistent width, etc.), that foul weather motorists would mistake seals for lane markers. Whether this will be a concern in all cold weather climates is unclear.

### **CONCEPT SPECIFIC FINDINGS**

#### **CONCEPT 1--CART-MOUNTED APPLICATOR**

##### **CONCERNS**

#### Wheels tracking through sealant

Crack sealers feared that tracking the wheels through fresh sealant work would be unavoidable, would frequently clog the cart's wheels, and would unshape newly-applied sealant. They proposed more clearance between the wheels and the cart to address sealant build up.

#### Many parts to break

Interviewees foresaw many possible maintenance points with the cart, regardless of whether or not this would actually be the case.

#### Ergonomics

A couple of crack sealers predicted that the twisting forces necessary to operate the cart would be at least as likely to produce back injury as the lifting forces necessary with the current crack sealing methods. All other interviewees felt the cart would be easier on a worker's back, however.

## Maneuverability/weight

Several crack sealers in Nebraska predicted control of Concept 1 would be cumbersome, and felt a two-wheeled cart which tipped back and forth with the sealant applicator between the wheels would be much easier to control.

## Physical effort to hoist system for transport between crack-sealing sites

This was a unanimous concern among California cities and counties since most reportedly seal and travel between several bunches of cracks during a typical day of sealing.

## **CONCEPT 2--ARTICULATING-ARM-MOUNTED APPLICATOR**

### **BENEFITS FORESEEN**

#### Ergonomics and Control

There was an immediate and unanimous reaction that the arm would be easier and more comfortable to control than Concept 1.

#### Flexibility

Local crack sealing agencies liked the idea of being able to put the operator on the road to seal at roadside (and under bushes, trees etc.), and off the road under conditions of limited traffic control.

#### Safety

The hose is attached to the articulating arm so it will not flap around, spewing 350-degree sealant, if it breaks--two workers in one local California agency have been burned this year. This benefit was mentioned at the beginning of the report, and although present with all concepts under evaluation, is strongest with the articulating arm because it binds the hose in more points than the other concepts and hence allows the absolute least freedom to move if a hose breaks.

## **MINOR BENEFITS FORESEEN**

### Hose life

Participants felt that hoses would last longer since attachment to the arm would prevent repeated acute bending in any specific areas.

## **MAJOR CONCERNS:**

### Logistical

Under current methods, when sealing a section of road with cracks that span the entire lane width, a worker starts on one side of the lane and seals to the other. By walking backwards and to the side of cracks just sealed, the worker avoids stepping in fresh sealant. To seal the last crack in the lane, workers straddle the crack and seal backwards, which allows them to avoid (1) stepping all the way into the next lane with uncontrolled traffic, and (2) stepping in fresh sealant work (the worker only needs to place one foot on the side of the seal-in-process crack where the fresh seal work is located, making it easier to avoid).

In all sealing positions across the lane, crack sealers say they need to seal backwards, i.e. they walk backwards, behind the trailer, sealing cracks as they come into view. This allows them to track recent seal work and touch up settlements or misses before the forward motion of the truck takes them out of range.

In light of the above, crack sealers felt that the articulating arm would be more difficult to handle than the hoses/wands, when trying simultaneously to avoid excessive exposure to traffic, fresh sealant, hot hoses, links in the arm, and when trying to touch up settlements and misses before the truck moved too far forward.

Crack sealers were very concerned about winding up with the arm in unwanted positions relative to their bodies as they concentrated primarily on positioning the applicator over cracks. Consequently, they foresaw many positions during sealing with the arm where the worker would have to stand beside or behind (rather than in front of) the applicator, or where the worker would have to walk forwards behind the applicator and seal forwards. Each would cause a unique problem:

Standing beside (rather in front of) the applicator at the edge of the work lane, the worker might venture too far into the adjacent, un-traffic-

controlled lane. Sealing forwards to avoid tangling up with the applicator, the worker would miss touch up opportunities. With the arm limiting where the worker could stand relative to each point of sealant application, as well as partially blocking the view of the ground, a higher incidence of stepping in fresh, hot sealant work could arise. And lastly, failing to take into account the position of the arm could result in a pinch or burn.

The participants conceded that the only way to resolve these issues would be to test the system. And they said that if a way was found to overcome these potential problems and improve some area of crack sealing (such as worker comfort from not having to vertically support the hose) without hurting the productivity of their crack sealing on the whole, they would be interested in purchasing and would put their workers through any special training necessary on use of the new equipment.

To address their concerns, participants suggested running the linkage or arm over the worker's head, which appears infeasible. One potential solution might be mounting an L-shaped, inflexible arm on the side of the back of the truck or trailer. The arm would protrude back from the trailer 10 or 12 feet and then bend inward and stop in the middle of the lane. The articulating arm would then attach to the L-shaped arm at a point that would effectively be the middle of the rear of the crack-sealing workspace behind the truck. The worker could then seal backwards with the arm and applicator in front of him. When sealing the side of lanes, he would now be able to roughly straddle the back of the applicator and walk backwards, as is currently done with the wands.

A second logistical concern emerged for only one participant, who said he would have a hard time reaching the sides of the road with this option, specifically when he needed to bend over and get under bushes. He still felt he would prefer the hose in this particular scenario.

### Maintenance/wear

Participants were very afraid of wear between links and pins due to both weather exposure and time.--"Would we have to grease it often?"

### Tolerance to vehicle position

Participants were afraid that the arm would be harder to control than the standard hoses if the truck moved forward slightly while they were holding it. They perceive the arm as being less flexible or at least

having a lot more inertia or resistance to changes in position due to weight.

**Note:** If the arm is harder to control amidst small changes in truck position, this could perhaps be addressed through some combination of training and closer (through radio) communication between sealer and driver.

### Lever control

There was a unanimous and extreme degree of skepticism expressed regarding the possibility of controlling the sealant applicator from a truck bed with a pole, due to inertia and lack of leverage.

## **MINOR CONCERNS**

### Getting pinched or hit by the links or arm

A mild concern was expressed over the possibility of workers being pinched or hit by movement (swing or bend) of the arm which could catch them off-guard.

### Flexibility at the base of the arm

When the truck or trailer is on a different grade than the arm, the base of the arm (where it attaches to the trailer or truck) will have to be hinged to allow equal pressure on the applicator--(this is probably already a feature). Participants accepted that the applicator would float to tolerate bumps in the road way, and saw this concern as separate.

## **CONCEPT 3--SERVO-DRIVEN, ARM-MOUNTED APPLICATOR**

### **MAJOR BENEFITS FORESEEN**

#### Safety

Operator is in a chair, they assume with a safety restraint, rather than standing.

#### Protection from the elements

Nebraska says workers would all want to crack seal if they could sit inside the cab and escape the cold.

## **MAJOR CONCERNS**

### Overkill for cities and counties

Local agencies interviewed considered the expense of the servo arm package unjustifiable amidst the benefits they foresaw for their crack sealing operations. They estimate that they do not seal enough long patches of road to reap enough reward from faster sealing to justify the extra expense of the system.

### Too expensive for an augmentation

The agencies interviewed doubted they would be allowed to buy an add-on package which approached or exceeded the cost of their entire current crack sealing equipment ensemble (trailer melter, wands, etc.). The add on would have to be very attractive in terms of greater productivity/speed. TDC estimates this concern could be overcome if the ACSM equipment was fast enough to justify the extra expense.

### Productivity

Crack sealers would have to see a demonstration to believe this servo system seals faster than the manual hose method currently used--most of them very much doubt that it can--see "field of vision" below.

### Safety

Introduction of mechanical forces means higher potential for injury and increased awareness required during operation.

### Field of vision

Crack sealers report that when sealing cracks, the truck keeps moving slowly, so it is necessary to have several views of the work area: (1) a detailed view of the crack being sealed, (2) an overview of the crack work just performed sufficient to spot settling sealant in time to perform a second seal before the truck moves too far forward, and (3) a detailed view of the cracks approaching so that especially dense areas may be given extra attention in an attempt to seal them all without stopping the truck and trailer.

One former crack sealer and supervisor of crack sealing likened the process to "...being in the NBA." He explained that crack sealers must



constantly adjust their vision from the crack being sealed to cracks approaching to cracks just sealed (but still within reach of the hose) in order to seal all cracks without having to stop the truck. This particular person was adamant that the screen method, even with the three views described above, could not afford clear and flexible enough vision to match the quality and productivity he currently achieves--"...you have to be right on top of cracks to seal them and spot flaws in recent work."

### Maintenance/downtime

Agencies see this as something that will be expensive and inconvenient when it breaks, requiring a trip to a special location for repair, consuming substantially more downtime than the current equipment when it is repaired.

### Skill to operate pantograph

All participants predicted it would be tedious and difficult, like a video game, to control the arm with the joystick--this may be totally untrue, of course, but that was the perception.

## **OPPORTUNITIES FOR ACSM TECHNOLOGY**

### Develop a melter which heats material faster

Agencies complain it takes four or five hours to heat sealant material before work can begin. And faster sealers also complain about running out of material during sealing as their application speed outruns their melting capability.

### Crack-sealing budgets will not shrink with a more efficient method

There was a consensus that at least the same amount of money would be spent on crack sealing if a more efficient method was developed. Furthermore, participating agencies estimated that they achieve only 75 to 80% of needed crack sealing per year in their jurisdiction (actual estimates ranged from 50% to 100%), indicating that a more efficient method would be very valuable.

### Personnel shortage

There is a reported manpower shortage as budgets are cut, and the elimination of the squeegee person is an important benefit for public

agencies, most of which still employ a squeegee operator in their crack seal configurations.

### Develop a vacuum routing system

One private contractor said that debris from routing makes subsequent crack work tedious and always requires street sweeping. A system which vacuumed up debris during routing would hold the potential for a large increase in productivity, according to this contact. Crafcoc does have a system for straight routing work on "rumble strips" (sections of road on which tires make noise) and recessed pavement markers (to sink pavement markers low in the road so that snow plows do not hit them); this system does vacuum up routed debris, but is not effective on random or curved-crack routing (Rich Reeder, Crafcoc).

### Performance criteria

The performance criteria of choice among those interviewed is pounds of sealant which can be laid per unit of time. If the ACSM team can demonstrate an improvement under this criteria, the devices will be considered more productive. Improving the speed of processing material is key in this regard, however.

Based on reports from anonymous industry sources, the fastest private crack sealers can apply sealant at rates just over 1,000 lbs of material per hour under ideal conditions (i.e. dense cracking per lane mile, optimum temperature for melting sealant, etc.). The faster public agencies can reportedly achieve up to half of that production, also under ideal conditions. The ACSM equipment team must meet these criteria to demonstrate superior productivity.

### Longitudinal sealing

Estimates of percentage of total crack sealing time spent on straight, longitudinal cracks vary greatly but are as high as 20 to 25 percent. If an automated longitudinal sealing system which is faster than the current method can be developed, with routing or heating, and blowing before crack sealing, there appears to be market potential. Several issues must be overcome, however.

Agencies are very resistant to purchasing a system which locks them into longitudinal sealing, because they foresee having to duplicate

traffic control if their longitudinal sealing operation outruns their general sealing operation.

However, if a longitudinal system could be developed which removed workers from the ground, which worked independently of the general sealing operations (going to sections of road and just sealing all the longitudinal cracks regardless of what the general crews were doing at the time), and which sealed very quickly, it does not appear that the same traffic control constraint would be operative. A favorable sign in this regard is that Crafcro sells an automated router which works only on straight cracks (though not just longitudinal straight cracks); this indicates that some agencies have been willing to fit a piece of straight-crack-only equipment into their protocols.

Private contractors said there are no "longitudinal-only" sealing jobs in crack sealing, but that they would still be interested in a method which truly sealed longitudinal cracks more cost-effectively than their current methods.

One private contractor said he is capable of sealing longitudinal cracks very quickly at present, just by duct-taping a wand to the side of the front of a truck and letting the driver position the wand over the crack by steering the vehicle. This method is very inexpensive compared to the new sealant applicator and undoubtedly produces a lower quality seal.

If using the new sealant applicator, the contractor conceded that sealant would settle in less places than with his duct tape method. But, he went on to explain, it would still settle in at least a few places, which would necessitate a return trip (any resettling at all means a return for a touch-up). Though less seal work would be required on this return pass than with his current method, he would still spend a very comparable amount of time on most sections of road, in his opinion. On this basis he rules out the extra cost of the sealant applicator for him at this time.

One difficulty in getting the market to value the sealant applicator in this longitudinal scenario (as well as others) seems to derive from a reported absence of standard expectations of seal life under different conditions;--instead, there are only protocols for seal height, preparation of cracks, etc. Private contractors reportedly do not make and are not required to make seal performance or life claims; instead, they only need fulfill the spec in the contract (i.e. routing or heating before sealing, dimensions of the band-aid, etc.).

If the findings from the SHRP program lead to an emphasis on seal life as well as standard expectations of seal life under different conditions, the extra expense of the sealant applicator relative to the duct tape method described above may suddenly be easily justifiable for private contractors and public agencies alike.

Also, if the sealant applicator can be shown to be much faster than the duct tape method (with a more sophisticated system for aiming the applicator at the cracks, for example), this might sway private contractors and agencies toward the applicator, without an increased emphasis on seal life expectations.

A faster longitudinal application method coupled with a proportionately faster system of melting material may thus be feasible if the above obstacles can be overcome.

## **OTHER MISCELLANEOUS FINDINGS**

### Filling versus sealing

Research indicates that about 20% of total crack work in the United States is filling and 80% is sealing (anonymous industry contact). If the filling market is to be addressed, the sealant applicator's function will have to be modified to include regulation of sealant (as crack depth and volume increase and decrease) to insure a complete fill. According to industry contacts, however, there is a trend towards sealing currently, so it is probably undesirable to address the smaller and reportedly diminishing filling market.

### Suggested sales strategy for new crack sealing equipment

In order to sell the preferred concept to agencies like themselves, those present suggested the following steps in the following order:

1. Contact of a street superintendent or maintenance supervisor
2. A short demonstration of the machine (with a salesperson who "knows how to run the equipment")
3. A one to two week trial in their agency.

### Lag time before purchase

The average public agency would require nearly eight months after initial contact regarding new crack sealing equipment before it purchased.

### Sealing procedures among agencies present

1 out of 8 route before sealing  
4 out of 8 blow  
4 out of 8 fill rather than seal  
all heat if using hot sealant  
50% use hot sealant  
50% use cold

### Materials used by crack sealers contacted

FDR  
CRF (2)  
Tri-American  
Seal All  
Poly Flex  
Asphalt Rubber Crafcro products used (24 total) Polyfiber, Polyflex, Road Savers, Asphalt Rubbers--all hot applied)

### Adjustable flow with current wands

Wands currently used can be made to dispense more sealant when application speeds or slows. This is said to be valuable when filling, since deep, wide sections require greater flow, or on a "straight shot" when sealing, for extra speed.

### Recirculation

Potential users would like the sealant to recirculate without a manual detachment of the hose. The current equipment does not continuously recirculate when the wands are not being used without a manual step either, so failure to address this point should not hurt sales. Overcoming this limit, however, would be a strong point differentiating the new equipment from the status quo.

### Fewer options for rotation of crew members between physical tasks

Considered to be a possible problem by one of the engineers on the ACSM team, this turns out to be a non-issue due to the many manual positions which will still be available in a crack sealing configuration (traffic control, etc.), and into which workers can be rotated.

## **CONCLUSIONS**

### **CONFIGURATION IN WHICH TO OFFER ACSM EQUIPMENT**

In regard to getting the operator off the ground, the PR value of doing this is fairly high, but the market value is low, so it must be done with very little additional expense beyond the operator-on-the-ground systems if it is to be done at all.

Furthermore, it appears that OSHA will quite possibly forbid any design which places an operator on a trailer. This fact coupled with the insistence that the melter be trailered rather than trucked (see numerous reasons above), and coupled with the need to have the operator seated and restrained, leaves only one possible scenario to get the operator off the road surface during crack sealing: Concept 3, the screen option, with video monitor in cab of truck, truck pulling a trailer, and servo arm and camera attached to the back of the trailer.

### **PREFERRED CONCEPT AND OPTION**

All crack sealers interviewed strongly preferred Concepts 2 and 3 over Concept 1.

The favorite was Concept 2, with the arm attached to trailer and the operator on the ground. All except one agency preferred Concept 2 overall. Agencies interviewed expressed a preliminary willingness to pay as much as \$17,000 for this concept--(\$5,000 over the estimated price) if all of the concerns found under "Concept Specific Findings, Concept 2" could be overcome.

Nebraska State Department of Roads preferred Concept 3 overall, but only in the exact configuration described above (video monitor in cab of truck, truck pulling a trailer, and servo arm and camera attached to the back of the trailer), and provided that it sealed enough more efficiently/productively than their current systems to justify the extra expense.

### **THE NEXT STEP**

One general finding is that to be successful, the new equipment must improve either productivity or safety in crack sealing without hurting the other. If the innovations improve safety, they must be at least as productive; and if they improve productivity, at least as safe.

Productivity encompasses speed of sealant application, speed of melting the material, cost of equipment, and all other factors which impact cost-effectiveness in crack sealing.

For the reasons offered in this report, most crack sealers interviewed feel that the new designs show potential to significantly improve safety in crack sealing, but doubt any of the concepts can seal as quickly or cost-effectively (productively) as current methods. Below is a recap of major issues driving skepticism about potential productivity:

**All concepts:**

- Bottleneck: Speed of melting material limits value of increased application speed.
- Inertia.

**Concept 1:**

- Wheels tracking through sealant.
- Maneuverability/weight.

**Concept 2:**

- Logistics of avoiding fresh sealant and traffic with the arm.

**Concept 3:**

- Flexibility/acuity in field of vision.
- Ability to seal fast enough to justify expense over current method.

TDC urges the ACSM team to ponder the possible constraints on productivity of the new designs presented in this report, decide which constraints are non-issues and which can be successfully addressed with design modifications, and meet with TDC for discussion before proceeding further. At present, from among all concepts evaluated, TDC feels Concept 2 shows the most promise for prototyping and beta testing.

# **APPENDIX: DESCRIPTION OF NEW SEALANT APPLICATION CONCEPTS REFERRED TO IN THE REPORT AND USED IN FOCUS GROUPS AND IN-DEPTH INTERVIEWS.**

## **SUMMARY OF NEW SEALANT APPLICATION SYSTEMS**

Operations using the new sealant applicator improve safety and efficiency in crack sealing. In the following designs the operator is responsible for moving the applicator in the horizontal plane of the roadway while the weight and vertical orientation of the unit are supported mechanically. Designs are presented in order of increasing sophistication.



## **DESCRIPTION OF SEALANT APPLICATOR**

- Applies sealant in a continuous patch as it passes over a crack
- Automatically meters the flow of sealant under a controlled pressure to
  - a) completely fill the crack
  - b) form sealant into a smooth patch along the road surface
- Operation is limited to two functions (after pressure and width of patch are set):
  - a) switching the flow on and off
  - b) passing the unit over the crack being sealed

## **FEATURES**

- **Applies sealant and finishes surface in one step**
- **Applies sealant under automatically-controlled pressure to insure equal volume of sealant laid per foot when operator speeds or slows application**
- **Quick disconnect of sealant supply hose at the applicator**
- **Self-contained heating system in the applicator**
- **Charged air cylinder allows float of applicator on road surface**
- **Quick adjustment of width of sealant applied (from 3" to 5")**
- **Immediate stop of sealant when button is pushed**

## **Notes:**

1. Works with both oil-jacketed and non-oil-jacketed systems.
2. Applies hot or cold sealants--even cold-applied thermosetting materials and fiber-modified sealants

## **BENEFITS**

- **One less person on the road since sealant is shaped as applied**
- **Faster sealant application--up to 15 ft/s (10 mph)**
- **Comfortable to use**
  - a) **no vertical lift required when steering applicator**
  - b) **applicator floats over bumps without hanging-up**
- **Higher quality, more consistent seal**
  - a) **volume of sealant laid per foot is always the same, regardless of changes in application speed**
  - b) **shape is more consistent than with current methods**
  - c) **sealant always hits pavement at optimum temperature**

- **Save sealant by lessening width of strip applied when appropriate**
- **Works with existing melter systems--no changes required**

## **CONCEPT 1 - CART-MOUNTED**

### **DESCRIPTION**

The applicator is supported on a cart and controlled with an adjustable-height handle. For comfort and easy handling, at least two of the three wheels of the cart are on casters, and the applicator is mounted off-center and counterbalanced with a weight. The cart/applicator assembly attaches to a standard melter trailer via the hose from the melter.

**Note:** Operator of cart is wired to driver to optimize vehicle position and speed with respect to crack sealing at all times.

### **FEATURES**

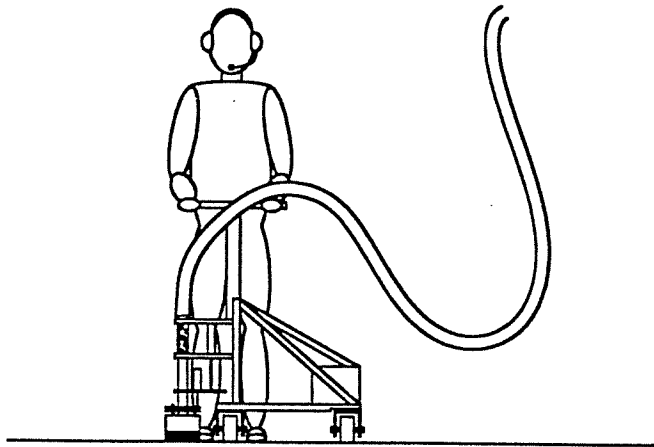
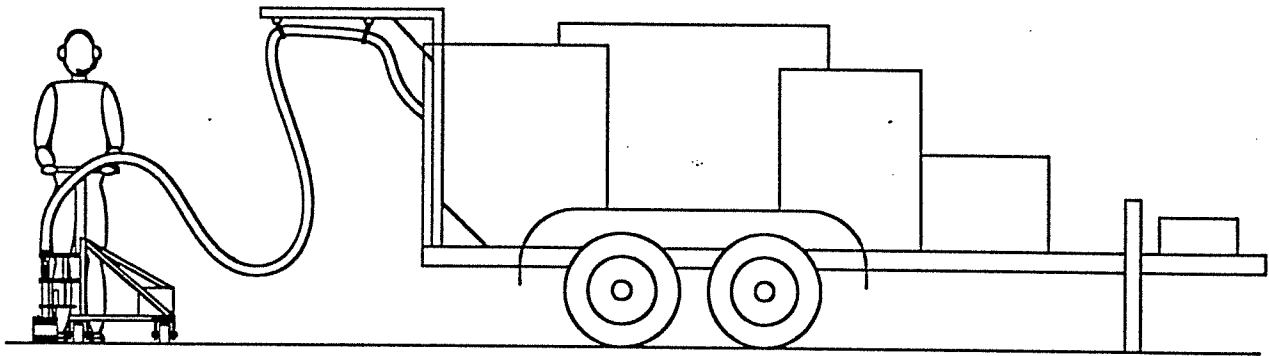
- **Connected to sealant supply only at the sealant hose**
- **Simple design**

### **BENEFITS**

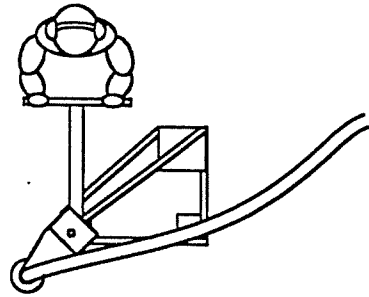
- **Speed--seal at least as fast with one person as you now can with two:**
  - a) **wand stroke is no longer necessary**
  - b) **operator can speed up on straight sections of crack and still lay the same volume of sealant per foot**
  - c) **sealing on the wide strip setting may allow faster sealing because it is easier to hit cracks**
- **Workspace limited only by hose length**
- **Low acquisition and maintenance costs**
- **Melters are not dedicated to this equipment--Melter trailers can still be used with the standard wands and squeegees through quick detachment of cart/applicator--if desired.**

### **APPROXIMATE COST (Excluding Melter and support vehicle)**

Cart-mounted applicator system	\$5,500
Generator and Compressor	\$3,500
<b>TOTAL</b>	<b>\$9,000</b>



SIDE



TOP

# CONCEPT 1

## **CONCEPT 2 - ARTICULATING ARM**

### **DESCRIPTION**

A lightweight arm with 8 to 10 links is attached to the rear of a standard melter trailer or truck (containing melter) and rotates smoothly in a horizontal arc which allows the sealant applicator to reach 8 feet to either side or to the rear of the vehicle. The links support the applicator vertically, yet follow the operator's horizontal movements as he follows a crack. Links can be added or subtracted as preferred. To stow the assembly between job sites, the arm can be easily restrained to the vehicle or trailer supporting it, and the sealant applicator pivots up from the road for increased clearance during transport.

**Note:** As with Concept 1, operator is wired to driver to constantly optimize vehicle positioning and speed.

### **OPTION 1: CONTROL APPLICATOR FROM THE GROUND WITH AN ADJUSTABLE-HEIGHT HANDLE**

#### **FEATURES**

- **Modular, multi-link construction**
- **No parts besides applicator contact the road**
- **Light weight**
- **Quickly-removable from truck or trailer**

#### **BENEFITS**

- **Easier to manipulate applicator than with Concept 1**
- **Speed--Faster than Concept 1**
- **Higher dexterity (sensitivity to small curves in cracks) than concept 1**
- **No running over fresh sealant**
- **Trucks and melters are not dedicated to this equipment**
  - a) **Trucks are easily liberated for other uses through detachment of sealant applicator and arm**
  - b) **Melter trailers can be used with the standard wands and squeegees through quick detachment of arm/applicator--if desired**

**OPTION 2--CONTROL APPLICATOR FROM VEHICLE OR TRAILER WITH A LEVER--**The operator stands on the bed of a large flatbed vehicle (or on a modified melter trailer) and controls the applicator with a lever.

**ADDITIONAL FEATURES AND BENEFITS OVER OPTION 1**

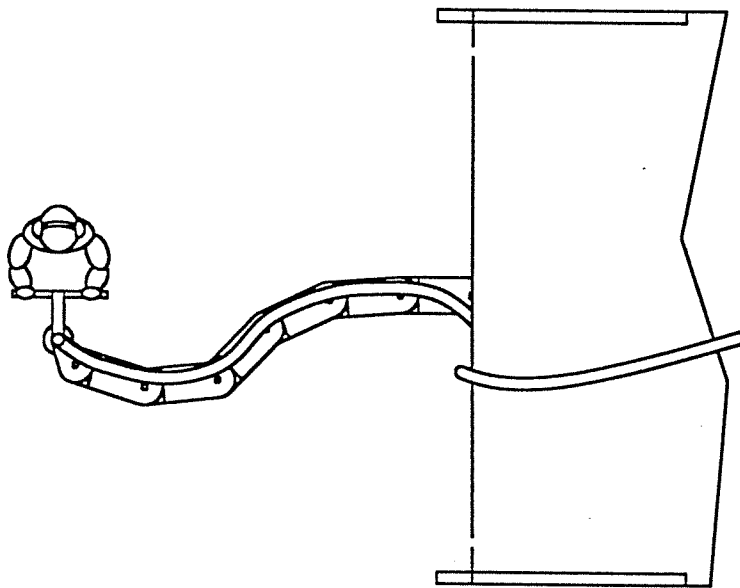
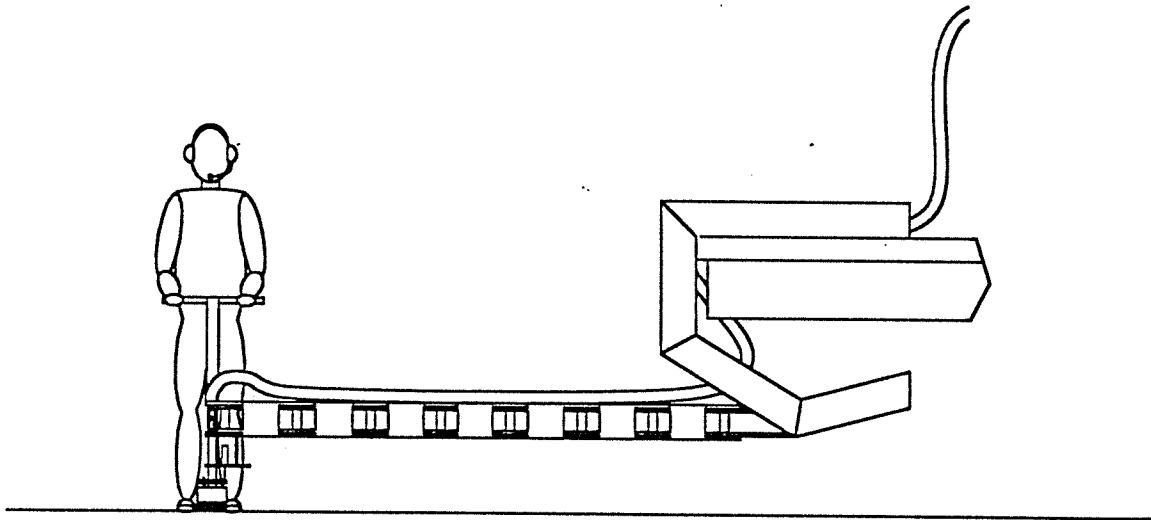
- **SAFETY:** Allows operator to stand on vehicle--**OFF THE ROAD**
- **SPEED:** Arm affixes to vehicle side for **FAST LONGITUDINAL SEALING--**By swinging the arm to one side and restraining the appropriate link with a brace to the truck, the operator can ride on the vehicle and use a lever to follow mostly-straight, longitudinal cracks at greater than walking speed--up to 15 ft/sec or 10 mph

**APPROXIMATE COST**

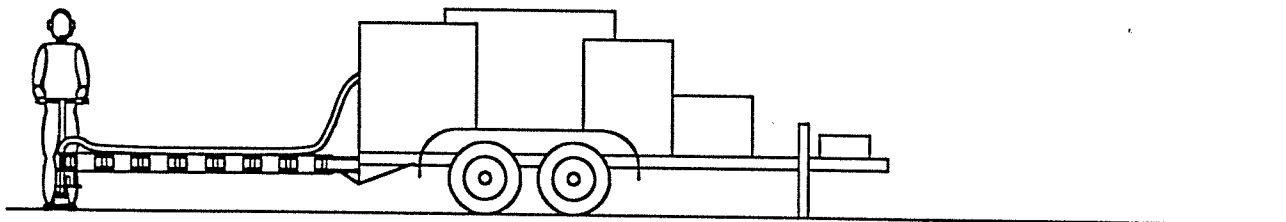
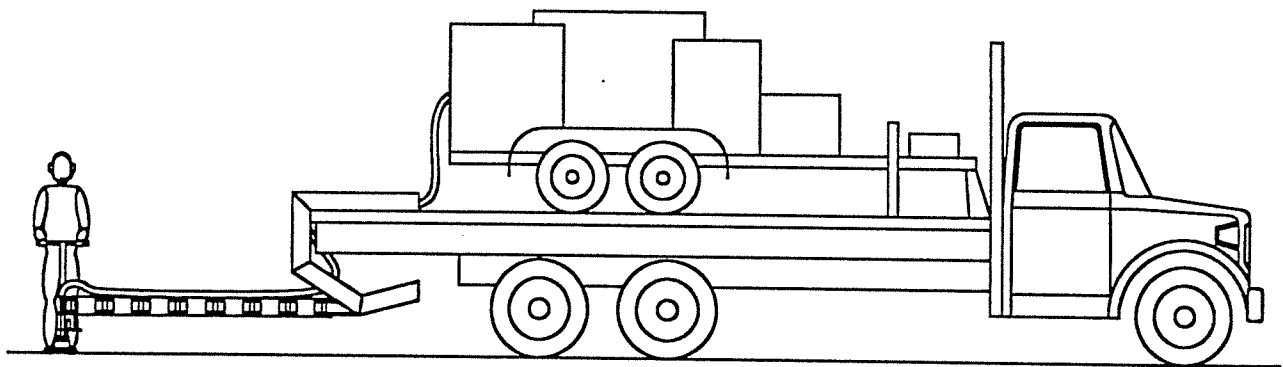
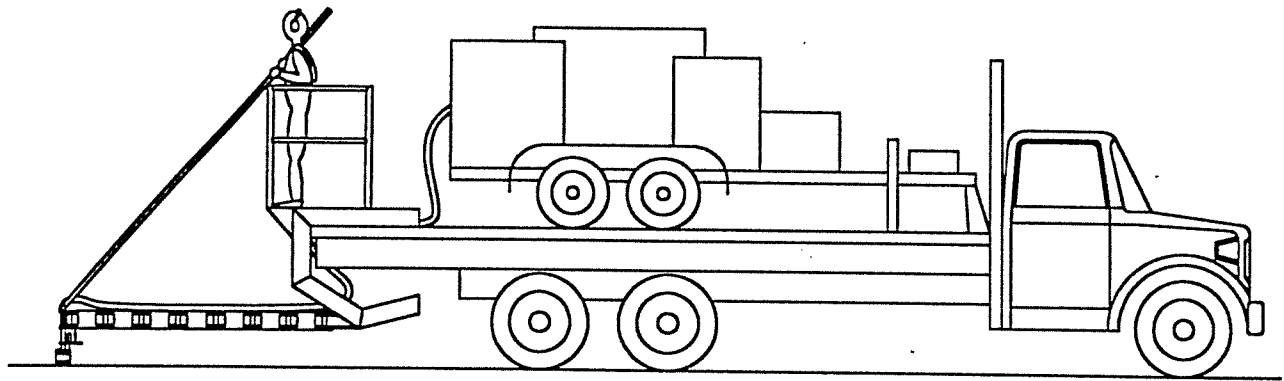
(Excluding melter and support vehicle(s))

Articulated arm-mounted applicator system	\$8,000
Generator and Compressor	\$3,500
Equipment modification	\$500
<b>TOTAL</b>	<b>\$12,000</b>

REAR OF TRUCK



# CONCEPT 2



## CONCEPT 2

# ATTACHMENT OPTIONS



## **CONCEPT 3 - SERVO-OPERATED ARM**

### **DESCRIPTION:**

Hydraulic actuators drive a two-link arm with a reach radius of 8 ft. Operator is seated in a control booth in the back of a large flatbed vehicle. He watches the applicator on the road and moves a pantograph control which translates his hand movements into movement of the two-link sealing arm along a crack.

**Note:** Again, operator wired to driver of vehicle for vehicle positioning relative to cracks.

### **FEATURES**

- **Applicator is manipulated by mechanical power**
- **Operator is up off the road**
- **Can be used to control other tools (i.e. blowers, heaters)**

### **BENEFITS**

- **Comfort--operator manipulates a hand-controller from a seated position to move sealant applicator**
- **Speed--FASTER than Concepts 1 and 2:**
  - a) **No longer limited by physical strength**
  - b) **Again, sealing on the wide strip setting may allow faster sealing because it is easier to hit cracks--speeds of several feet per second are possible**
  - c) **Again, very fast longitudinal sealing**
- **Safety--operator off the road and away from moving parts**
- **Truck not dedicated to crack sealing**

### **APPROXIMATE COST**

(Excluding melter and support vehicle)

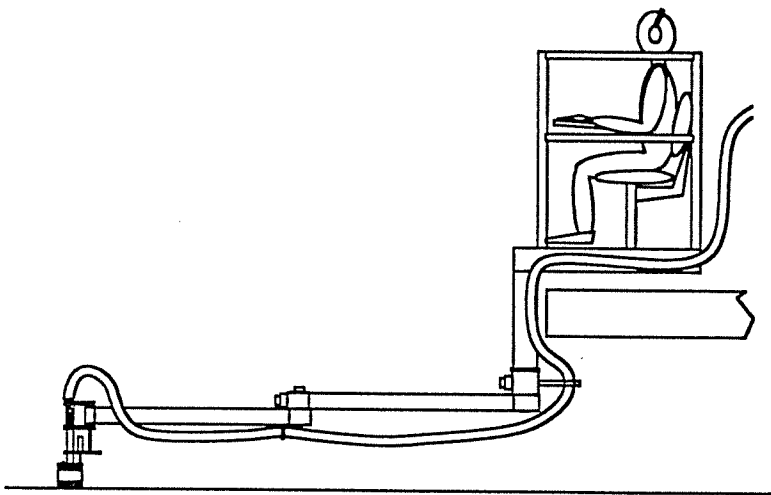
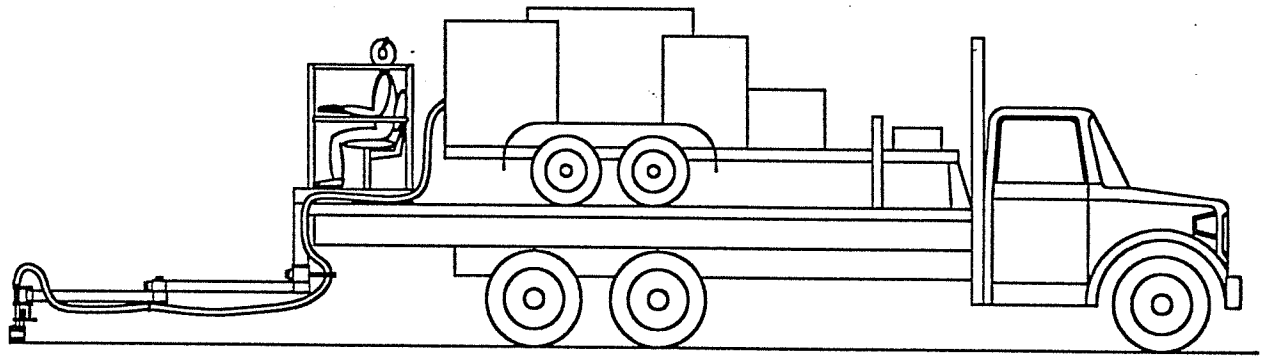
Servo arm system	\$14,000
Hydraulic Power System	\$3,000
Approx. 10 gpm 2000psi	
Generator and Compressor	\$3,500
Equipment Modification	\$500
<b>TOTAL</b>	<b>\$21,000</b>

**SERVO ARM, OPTION 2--Add a video screen.**

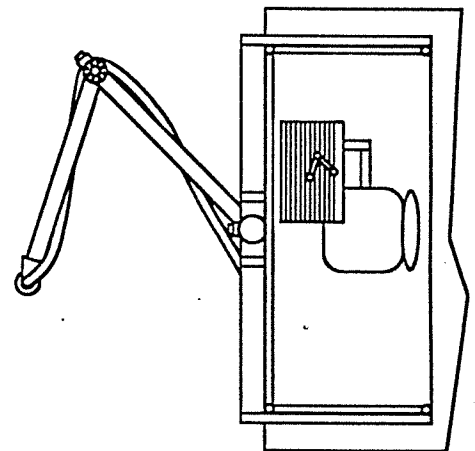
**DESCRIPTION:**

The operator watches a picture from a camera directly above the sealant applicator. The screen and operator can be positioned at the rear of the vehicle as the picture indicates for a better view of cracks for fine adjustments when following them. Or the screen and operator can be in the passenger's side of the cab so that direct communication with driver (rather than through headset) is possible.

**TOTAL COST \$25,000 regardless of whether screen is in rear of vehicle or in cab.**

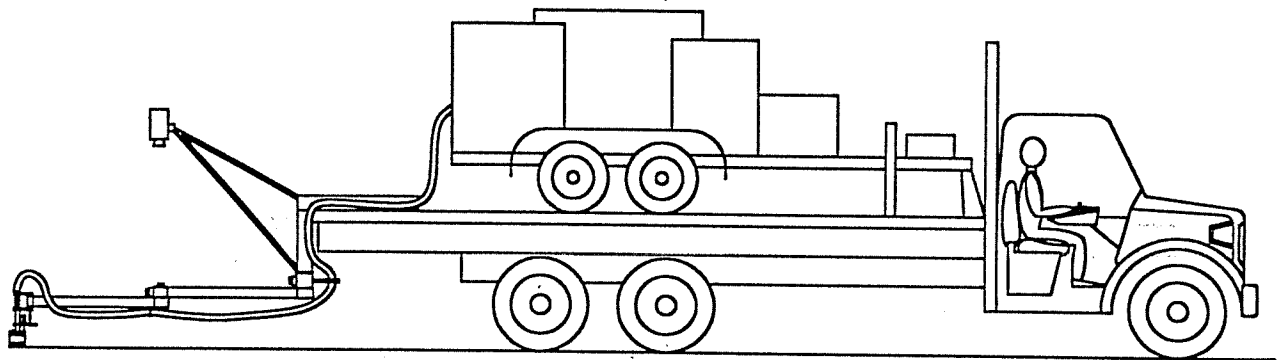


SIDE

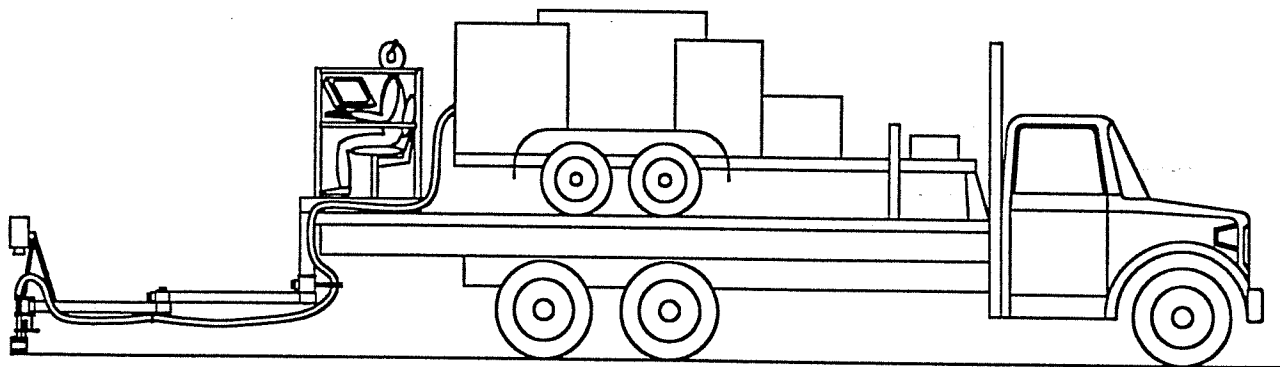


TOP

# CONCEPT 3



OPERATOR VIEW SCREEN IN CAB



OPERATOR VIEW SCREEN IN BACK

# CONCEPT 3