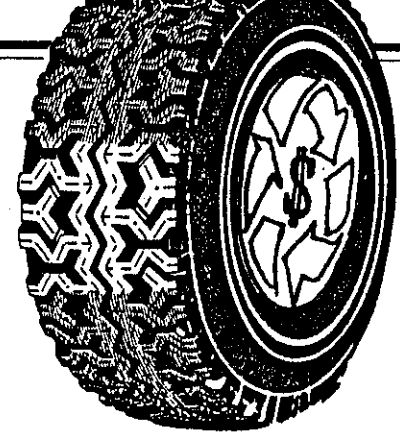

SCRAP TIRE RECYCLING

AND

VENDOR'S WORKSHOP

SPONSORED BY

Fayetteville Technical Institute Continuing Education

North Carolina Association of County Commissioners

Cumberland County Clean Community Committee

Supported by the North Carolina Pollution Prevention Pays Program
with funding through the North Carolina Board of Science and Technology

NOVEMBER 13, 1986
Fayetteville, North Carolina

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SCRAP TIRE RECYCLING

AND

VENDOR'S WORKSHOP

COSPONSORED BY

FAYETTEVILLE TECHNICAL INSTITUTE CONTINUING EDUCATION

NORTH CAROLINA ASSOCIATION OF COUNTY COMMISSIONERS

CUMBERLAND COUNTY CLEAN COMMUNITY COMMITTEE

NOVEMBER 13, 1986

FAYETTEVILLE, NORTH CAROLINA

Supported by the North Carolina Pollution Prevention Pays Program with funding through the North Carolina Board of Science and Technolog

Fayetteville Technical Institute Continuing Education
North Carolina Association of County Commissioners
and Cumberland County Clean Community Committee
"Scrap Tire Recycling and Vendor's Workshop"
November 13, 1986
FAYETTEVILLE, NORTH CAROLINA

8:30-9:00 *Registration*

9:00-9:15 *Welcome: Introduction*
Dr. R. Craig Allen, *President, Fayetteville Technical Institute*
Virginia Thompson Oliver, *President, North Carolina Association of County Commissioners*

9:15-10:00 *Overview of the Problem: Panel*
State - Roger Schecter, *North Carolina Department of Natural Resources and Community Development*
Solid/Hazardous - Terry Dover, *North Carolina Department of Human Resources*
Local Perspective - Betsy Dorn, *Mecklenburg County Engineering Department, Charlotte, North Carolina*
Bob Stanger, *Cumberland County Engineer, Fayetteville, North Carolina*

10:00-10:20 COFFEE BREAK

10:20-12:00 N *Recycling Opportunities/Overview of Technology*
Fred J. Stark, Jr., *Elastomerics, Inc., Minneapolis, Minnesota*
Raymond Dzimian, *Baker Rubber, Inc., Buffalo, New York*

Tire-Derived Fuel/Resource Recovery Systems
Robert Herrmann, *American Ecology, Timonium, Maryland*

Asphalt Rubber National
Russ Schnormeier, *Engineer, City of Phoenix, Arizona*
Bob Bennett, *Engineer, City of Fayetteville, North Carolina*
Dr. Raymond Pavlovich, *Plus Ride, Albuquerque, New Mexico*
Pat Strong, *North Carolina Department of Transportation*

Pyrolysis
Geoff Tyson, *Vice-President, Nu Tech Systems, Chicago Illinois*

12:00 N-1:30 LUNCH

1:30-3:00 *What Are Other States Doing?: Approaches*
Overview: National - Mark Hope, *Waste Recovery, Inc., Portland, Oregon*
State - Shelly Sporer, *Minnesota Pollution Control, Roseville, Minnesota*
Richard Keller, *Government Procurement, Maryland Office of Energy, Baltimore, Maryland*
Dr. Raymond Pavlovich, *EPA Guidelines*

3:00-3:15 COFFEE BREAK

3:15-5:00 *The Challenge:*
Panel: Mark Hope, *Collection System/Generation*
Frank Pace, *NC Department of Transportation*
Pat Strong, *NC Department of Transportation*
Shelly Sporer, *Legislative Framework/Local Ordinances*

Questions and Answers: Morris Bedsole, *Chairman, Cumberland County Commissioners*
Dan Stryck, *Kelly Springfield, Industry Representative*
Robert Smith, *Executive Vice-President, NC Tire Dealers and Retreaders Association, Inc.*

5:00 ADJOURN

Fayetteville Technical Institute Conference Coordinators
Sheridan Turpin • Sharon Valentine • Terry Church

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Tire Disposal in North Carolina-
The State Prospective
by
Terry F. Dover

I. What is a Solid Waste?

A. Definition contained within N.C. Solid Waste Management Rules

B. Tires - are solid waste by regulatory definition

II. Experiences with Tire Disposal since 1970

A. Illegal dumps, size ranging from a million to simple storage around businesses

B. Public health significance, tire sites

1. Vector breeding, i.e., mosquitoes

2. Air pollution and potential ground water, surface water pollution from fires

C. Approved waste for landfill disposal

1. Co-disposal with routine solid waste

2. Disposal in separate area, i.e., demolition area

III. Can Tires by Landfilled?
Yes

A. Landfilling is environmentally sound

B. Not a threat to ground or surface waters

C. Many landfills prohibit disposal unless sliced or quartered

D. Fees, special charges ranging from .25 to $1.00 for special handling

IV. Present Disposal Practices

A. Sanitary landfill

B. Mono landfill

C. Incineration

V. Special Ordinances by Counties

A. Prohibition on disposal

B. Prohibition on entry of waste from outside the county

. Regulatory Problem

A. Numbers of sites across North Carolina

B. Lack of recycling opportunities

. Needs for the Future

A. Regional cooperation

B. Realistic and dependable markets

C. Re-education of the general public

1. Cost associated with recycling

2. Manufacturers through consumers part of the problem

TIRE DISPOSAL IN MECKLENBURG COUNTY

Betsy Dorn

Mecklenburg County Engineering Department
700 North Tryon Street
Charlotte, NC 28202

Presented at Scrap Tire Recycling and Vendor's Workshop

Sponsored by Fayetteville Technical Institute
North Carolina Association of County Commissioners
and Cumberland County Clean Community Committee

Fayetteville, N.C.
November 13, 1986

I'm Betsy Dorn and I'm the recycling coordinator for Mecklenburg County and I know a lot about recyling a lot of different parts and materials but I have to admit that when I was asked to speak on this topic of the tire disposal problem and recycling tires, I had to do some self-examination and realized that I was very ignorant on the subject. I'm really here more to learn than to tell you some things but I did do some research for my speech and in the process I learned a lot myself and I think I can share some of the things listed. First of all, when I was asked to speak on this topic, I remembered something someone said in our solid waste management department who said it's not our problem. We just don't let tires in our landfill that are whole, just split in quarters and whole tires split up are just whole tires buried. As a result of us not allowing them in this area unless they are split or quartered we just don't get that many tires. The problem for us is a problem growing to the health department not on the solid waste department, the problem with tire disposal. I think this is a problem that falls through the cracks between departments in a lot of counties. Our county, Mecklenburg County, being so large has more departments and bigger cracks. The smaller counties may be able to cover things better. The tire problem in our county is more of an enviromental health problem right now. The Health Department has been addressing the problem through remedial approaches. How do we clean up tires? How do we control the burning of them? Our county has not been addressing from the proactive or preventive standpoint. I hope we can start doing that. I learned a lot about the tire disposal problem in our county. I didn't even realize that we had more tires registered in our county than we have people registered so there are a lot of tires that have to be managed. I didn't know that thousands of tires were being illegally dumped throughout our county and they're being stored in ways that prove to be harmful. I didn't know there were people in our county that in the past have capitalized on this situation of not allowing whole tires to be buried in our landfill. They decided to set up their on businesses and charge $1.00 a tire or whatever to haul tires. They'd rather dump them illegally on other people's property. Then these people decided to sell their property to someone they didn't know and we ended up with situations of 75,000 tires piled on someone's property and not being able to pinpoint who should have to clean this up. So the county and the city pays $15,000 to clean up these tires themselves and those tires were buried whole with a special permit from the state. In another situation a few years ago, there were hundreds of thousands of tires on one site in the county and a local man called and purchased that land and buried those tires on site and whole and when they surfaced, split them in quarters and reburied them. Obviously that is no way to manage tires. I didn't realize that there was only one old tire splitter in our county and he only does it occasionally so we haven't allowed whole tires in our landfill since there is no one out there to split or quarter them. One of the biggest problems that I found out was not the large illegal dumping of tires, it was the people like you and I who may change our own tires and then what do we do with them now. The city won't pick them up and when we put them out for garbage pickup, they are left so they go behind the garage out of sight and forgotten. That is how small amounts of tires are collecting around the neighborhood. That is the type of situation that our environmental health department gets complaints on. In 1979, our Mecklenburg County Environmental Health Department conducted a survey of tires generated by tire handlers and the data is valuable. Of those there are 303 tire handlers and of those, 47% are storing those tires in ways that breed misquitos and more than 30,000 tires were seen on the premises. The Environmental Health staff felt that 850,000 tires were disposed in the county that year. We have one large tire generator, General Tire, and 47,000 of those 850,000 tires were generated by that group. The remainder of over 570,000 tires were disposed of by retreaders and recappers. So clearly, there is a big industry in our county of recutting these tires for recapping and retreading but then they have to do something with those tires that can't be reused in that form. Sixty-eight percent of the businesses surveyed, had paid someone to haul these tires off. Few of them knew where their tires were dumped. When you think of this problem, the most interesting thing is that we have let this go on for so long in our county and clearly there needs to be some kind of government intervention because the private sector is not handling it effectively. We've got a lot to do in our county and I think that other counties can also say the same thing. Right now my engineering department has been focusing on these bigger problems and we consider this a priority. Now that I have done my research for this speech, I realize that we are going to have to address this problem too.

OVERVIEW OF THE PROBLEM-LOCAL PERSPECTIVE

BOB STANGER

Cumberland County Engineer

Presented at Scrap Tire Recycling and Vendor's Workshop

Sponsored by Fayetteville Technical Institute
North Carolina Association of County Commissioners
and Cumberland County Clean Community Committee

Fayetteville, NC
November 13, 1986

SCRAP TIRE RECYCLING AND VENDOR'S WORKSHOP

I HAVE BEEN ASKED TO GIVE A BRIEF OVERVIEW OF THE PROBLEM OF DISCARDED TIRES IN CUMBERLAND COUNTY AND TO RELAY SOME OF THE INITIATIVES THAT HAVE BEEN UNDERTAKEN IN THE COUNTY. AS WE ALL KNOW, THE PROBLEMS ASSOCIATED WITH THE DISPOSAL OF USED TIRES ARE WELL DOCUMENTED. WHEN BURIED IN A CONVENTIONAL LANDFILL, TIRES DO NOT SIGNIFICANTLY DECOMPOSE AND THEY HAVE A TENDENCY TO RISE TO THE SURFACE, COMPROMISING THE SUITABILITY OF LANDFILL SITES FOR FUTURE DEVELOPMENT. TIRES WHICH ARE IMPROPERLY DISPOSED OF, EITHER IN LANDFILLS OR LEFT ON THE GROUND, PROVIDE EXCELLENT BREEDING GROUNDS FOR DISEASE CARRIERS AND PESTS. STOCK-PILES OF USED TIRES HAVE PROVEN TO BE A THREAT TO PUBLIC SAFETY AND ENVIRONMENTAL QUALITY.

FIRES WHICH OCCASIONALLY ARISE IN STOCK-PILED TIRES ARE COSTLY AND DIFFICULT TO CONTROL. A SITUATION WHICH COMES TO MIND IS THE FIRE IN FREDERICK COUNTY, VIRGINIA WHICH BURNED FOR MORE THAN NINE MONTHS COSTING THE COUNTY MORE THAN $2,300 TO CONTAIN AND SIPHONED SOME 1.8 MILLION DOLLARS FROM THE SUPERFUND FOR CONTAINMENT AND CLEAN-UP OF THE MELTED-TIRE RUNOFF FROM THE SITE. WITHIN THE LAST YEAR, A FIRE OCCURRED IN A BUILDING IN DOWNTOWN FAYETTEVILLE WHERE USED TIRES FROM A LOCAL TIRE RETAILER WERE STOCK-PILED.

THE VOLUME OF DISCARDED TIRES GENERATED IN CUMBERLAND COUNTY IS MAGNIFIED BY THE PRESENCE OF ONE OF THE WORLDS LARGEST TIRE PRODUCERS, KELLY-SPRINGFIELD. BASED ON FIGURES OBTAINED FROM THE COUNTY SOLID WASTE DEPARTMENT, APPROXIMATELY 6,300 TONS OF TIRES ARE DISPOSED OF IN THE LANDFILL, OF WHICH 90 PERCENT ARE GENERATED FROM KELLY-SPRINGFIELD. IN ADDITION TO UNMARKETABLE TIRES WHICH ARE SLICED BY KELLY PRIOR TO DISPOSAL IN THE COUNTY LANDFILL, SPENT CARBON BLACK AND A RUBBER SLUDGE MATERIAL FROM THE TIRE MANUFACTURING PROCESS AND UNFINISHED RUBBER CONTAINING WIRE IS RECEIVED FROM KELLY-SPRINGFIELD.

ONE INITIATIVE UNDERTAKEN IN THE COUNTY WAS THE PREPARATION OF A CRUMB RUBBER FEASIBILITY REPORT BY THE INSTITUTE FOR LOCAL SELF-RELIANCE. THIS REPORT WAS PREPARED UNDER THE DIRECTION OF THE CUMBERLAND COUNTY CLEAN COMMUNITY COMMITTEE AND WAS FUNDED IN PART THROUGH A GRANT FROM THE NORTH CAROLINA POLLUTION PREVENTION PAYS PROGRAM. THIS STUDY INVESTIGATED THE FEASIBILITY OF SITING A SCRAP TIRE PROCESSING FACILITY IN FAYETTEVILLE AND THE OBJECTIVES OF THE STUDY INCLUDED:

- ASSESSING THE ECONOMIC VIABILITY OF THE TIRE RECYCLING REPROCESSING INDUSTRY FOR THE CUMBERLAND COUNTY REGION
- DETERMINING THE SOURCES, QUANTITIES AND AVAILABILITY OF SUPPLY WITHIN A DETERMINED RADIUS OF THE PROPOSED FACILITY
- DETAILING THE TECHNOLOGICAL OPTIONS FOR CRUMB RUBBER PRODUCTION AND RESPECTIVE COSTS
- ASSESSING THE POTENTIAL MARKETS

PREVIOUS ASSESSMENTS OF TIRE-RECYCLING FEASIBILITY INDICATE THAT THE PROCESSING OF TIRES INTO CRUMB RUBBER IS THE MOST PROMISING OPTION FOR SUCCESSFUL MARKETING OF PRODUCTS DERIVED FROM DISCARDED TIRES. THE THREE MAJOR POTENTIAL MARKETS FOR CRUMB RUBBER ARE AS A SUPPLEMENTAL FUEL, AS AN ADDITIVE FOR ASPHALT, AND AS A RAW MATERIAL FOR MANUFACTURING RUBBER PRODUCTS. SRI RECOMMENDED TO CUMBERLAND COUNTY CLEAN COMMUNITY COMMITTEE THAT IT WORK WITH LOCAL INVESTORS TO INITIATE A DETAILED ASSESSMENT OF THE MARKET FOR CRUMB RUBBER AS A FUEL AND ASPHALT ADDITIVE AND THAT IT MORE FULLY INVESTIGATE THE POTENTIAL OF THE TIRECYCLE PROCESS. THE TIRECYCLE PROCESS IS A NEW PATENTED PROCESS DEVELOPED BY A MINNESOTA FIRM THAT MAY MAKE POSSIBLE THE USE OF THE ENTIRE TIRE FOR THE RUBBER PRODUCTS MARKET.

A PROCESSING PLANT CAPACITY OF 150 TONS PER DAY WAS RECOMMENDED BY SRI BASED ON SUPPLY AND DEMAND FIGURES FOR A SERVICE AREA OF 150 MILE RADIUS FROM FAYETTEVILLE.

OTHER RECOMMENDATIONS CONTAINED IN THE CRUMB RUBBER FEASIBILITY REPORT WERE:

- FURTHER EXPLORE THE FEASIBILITY OF AN ENTERPRISE TO PRODUCE OIL THROUGH PYROLYSIS TECHNOLOGY
- ENCOURAGE THE NORTH CAROLINA DEPARTMENT OF TRANSPORTATION TO ADOPT STANDARDS AND SPECIFICATIONS FOR THE USE OF CRUMB RUBBER IN ASPHALT

ANOTHER INITIATIVE UNDERTAKEN BY CUMBERLAND COUNTY IS THE INVESTIGATION OF MASS BURN OF SOLID WASTE. SINCE 1979 THE COUNTY HAS BEEN STUDYING RESOURCE RECOVERY AS A LONG TERM OPTION FOR SOLID WASTE DISPOSAL. DISCARDED TIRES ARE AN EXCELLENT SOURCE OF FUEL HAVING A ENERGY VALUE OF APPROXIMATELY 12,000 BTU PER LB. AND WOULD SUPPLEMENT THE HIGH HEATING VALUE OF MUNICIPAL SOLID WASTE. THE SCRAP TIRES COULD BE SHREDDED PRIOR TO BEING FED INTO THE FURNANCE-BOILER. THE COUNTY SOLID WASTE DEPARTMENT IS CURRENTLY INVESTIGATING SHREDDING OF SCRAP TIRES AND WOOD PRODUCTS AS AN INTERIM MEASURE TO REDUCE THE VOLUME OF THESE MATERIALS PRIOR TO LANDFILLING.

LATER IN THE PROGRAM, MR. BOB BENNETT, FAYETTEVILLE CITY ENGINEER WILL BE DISCUSSING THE USE OF RUBBERIZED CRACK SEALANT IN THE MAINTENANCE OF ASPHALT PAVEMENT.

THANK YOU FOR THIS OPPORTUNITY TO SPEAK WITH YOU THIS MORNING.

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FAYETTEVILLE TECHNICAL INSTITUTE

T I R E R E C Y C L I N G C O N F E R E N C E

The opportunity to present the TIRECYCLE® process of utilizing waste tires is appreciated. The basic fact is that scrap tires have a negative value but they can be converted into a new basic raw material for use in the rubber and plastics industry. You have been exposed to the tire problem in this area and to some of the possible solutions to the disposal of used tires which include shredding for fuel, reduction through pyrolysis to produce oil and carbon ash. Other methods put forth used ground tire rubber as an additive for asphalt and using whole tires for erosion control, or simply shredding for land fill.

All of the above methods are feasible but miss the mark in that none of them provides enough value added to the final product to totally cover the processing costs. In short, in order to survive all require some sort of subsidy either through tipping fees collected from the generator or direct subsidy through taxation on the consumer. The TIRECYCLE® process produces end products that generate revenues in the vicinity of $500 per ton as opposed to $20 to $40 per ton for fuel. This high value added makes TIRECYCLE® the only really viable tire disposal method presently known.

Our approach differs from most others in that we will accept tires at our plant free of charge. We provide the present system of collectors (transporters) with a legal disposal site. Minnesota law forbids any accumulation of more than 500 tires without a permit. Permits will be issued only upon proof that tires collected will be disposed of only to approved processors. Since we do not charge for disposal we become the lowest cost disposal site in the state.

A typical collector charges the generator $1.00/tire to pick up and pays 50¢ to dump at a processor or a land fill. He can now deliver the tires to Babbitt and save the 50¢ dumping fee less his freight cost. Freight from the Twin Cities to Babbitt is approximately 25¢. Therefore he has increased his bottom line by 50%. In addition he has the possibility of a full rate back haul since everything that goes in to Babbitt has to come out as finished product. Load weights can be increased by proper loading, baling tires or designing special trailers to further enhance his return. We do not want to infringe upon the existing collection system. We simply provide the final disposal site for tires of all types and sizes.

TIRECYCLE® is the registered trademark of RRE and encompasses a wide spectrum of products that are produced from recycled scrap rubber. The TIRECYCLE® process involves taking whole tires, grinding them into varying particle sizes and then surface treating them with a patented liquid polymer so that the scrap rubber actively cross-links with the other particles which in turn enables it to be integrated into finished molded rubber products at high concentrations without affecting their physical properties.

TIRECYCLE® which sells for between 25 and 33 cents per pound can be substituted up to 100% for virgin rubber which has a selling price that ranges from 40 to 80 cents per pound. Depending on the concentration of TIRECYCLE® used, a compounder's raw material costs can be reduced by 20% to 50%.

Ground scrap rubber has been available and has been used in rubber compounding for an extensive amount of time; however, the level of usage has usually been limited to a low percentage (10%) in compounding. The specific advantage of TIRECYCLE® is its utility in compounding. A typical level of usage is 50% (i.e., equal weights of TIRECYCLE® and the virgin rubber compound). This high level of usage is unique to the industry. The cost savings for the compounder using TIRECYCLE® are phenomenal. TIRECYCLE® now becomes a major compounding ingredient in a huge market.

When concentrations of untreated ground rubber are used in a concentration greater than 10%, the physical properties of the end product usually fall off dramatically. The use of TIRECYCLE® is contrary to the expected in that it has been shown that concentrations of 25%, 50% and 75% affect the physical properties to only a minor degree and the degree of loss is reasonably constant regardless of the concentration. In addition, it has been shown that the size of the particulate has a minimal effect on the physical properties. Prior to the advent of TIRECYCLE®, all attempts at using particulate scrap were oriented towards achieving a smaller particle size. This approach can become very costly as particle sizes smaller than 30 mesh are attempted. Particle sizes in the range of 30 mesh are essentially the effective limit for fineness. The TIRECYCLE® treatment works quite well with a particulate finer than 30 mesh, but there is usually no need for this expense. This development provides a low cost base for the particulate scrap regardless of the source of rubber. For example, butyl is very difficult to grind finer than 10 mesh. The TIRECYCLE® treatment makes costly grinding procedures superfluous.

An additional aspect of this process is the exploitation of the scrap rubbers other than tires. All rubber molding produces a considerable amount of scrap rubber (5 - 15% is typical). It has been shown that the other types of elastomers can be used to great advantage. This allows a recycling of costly polymers -- Neoprene, butyl, nitrile, EPDM. To discard scrap rubber can be quite costly. Not only is there the loss of the compound, but disposal costs tend to be in the area of five cents per pound. A RRECYCLE™ program has been developed and can be offered to rubber molders whereby their rubber scrap can be ground, treated and returned to them for a toll charge. A typical compound cost of 55 cents per pound can be offset with a RRECYCLE™ charge of $0.25 to $0.30 per pound. These economies can be quite attractive to the compounder.

There are custom grinders of scrap rubber who presently solicit special grinding of scrap. They, however, can only provide a minimal service of grinding. The utilization of these other ground rubbers is limited in the same manner as is the tire scrap rubber.

One of the basic aspects of TIRECYCLE® is its use as an engineering material. Totally new end products can now be designed using TIRECYCLE® because of its low cost. One application is roofing shingles. This is significant because this is an area closed to regular compound rubber because of cost. TIRECYCLE® can be modified for color, for example, to meet the specific requirements. The adoption of TIRECYCLE® as a basic raw material in this area is heavily dependent on its availability. Stable supply rather than technical efficacy is the critical point. TIRECYCLE® would revolutionize residential roofing in the same way that single ply roofing has revolutionized commercial roofing. It must be noted that TIRECYCLE® fits with the single ply roofing, too, in terms of providing unusual services -- ballast walkway mats and recycling the scrap rubber of the EPDM single ply.

Another TIRECYCLE® use is in tire tread rubber for auto, truck, and off the road. Tread rubber with 40 to 50% TIRECYCLE® has been found to be equal or better than the basic rubber compound used. This is a basic approach to recycling. The salient point is that the TIRECYCLE® actually enhances the performance of the tread rubber. There are obvious cost savings, but the objective has been to realize significant improvements in performance. This is a market that is large and that has the capability of paying for performance.

At the present time there are no products directly competitive with TIRECYCLE®. There is ground scrap rubber which can hardly be competition for it is the starting point for TIRECYCLE®. There is reclaimed rubber which has been available on a historical basis and is still being produced in a large volume. It is basically produced by four suppliers with a currently estimated volume of 80 million pounds annually. Reclaiming involves a chemical process whereby rubber is devulcanized through the use of heat and solvents. The environmental hazards of the process have hastened the decline of the increasingly costly operations. Industry projections forecast the elimination of the reclaim industry within the next five to seven years. Reclaimed rubber is used in rubber compounding particularly as a process aid. The most interesting aspect of reclaim is that it works quite well with TIRECYCLE®, and TIRECYCLE® improves its general physical properties. Reclaimed rubber has been suggested as a compounding ingredient in conjunction with TIRECYCLE®.

It is particularly interesting that TIRECYCLE® has been utilized for a number of reasons other than cost. Ground rubber, for example, has often been used in a compound to reduce air trappage. The limitations of the concentration and loss of physical properties compromised its use. TIRECYCLE® can be used in any concentration and allows the compounder great latitude for adjusting and solving problems. The rate of cure is improved without increasing scorch. Usually the addition of ground rubber or reclaimed rubber retards the cure rate. Compression set resistance is improved. This is a very important factor in compounding. Usually the only way to improve compression set resistance is to make a harder compound. TIRECYCLE® allows softer compounds with much less compression set. Improvement is usually in the range of 25%.

TIRECYCLE® is a means of easily introducing reinforcing fibers in a rubber compound. Dispersion of fiber lengths greater than 1/2 inch are quite easily accomplished. RRE's approach has been to introduce a product called FIBRECYCLE™. FIBRECYCLE™ is a blend of ground rubber and fiber which is then surface treated. Blending fibers in the usual rubber processing equipment (mill and Banbury) produces knots of fiber, but when processed as FIBRECYCLE™ the fibers can be fully dispersed in the usual equipment.

The most significant point of FIBRECYCLE™ is that it can utilize the tire cord of the scrap tires. A tire is roughly 10% metal, 30% fiber and 60% rubber. Prior to TIRECYCLE® and FIBRECYCLE™ there has been no use for tire cord. The FIBRECYCLE™ products are usually 50% fiber and 50% particulate rubber. This allows using 75% FIBRECYCLE™ and 25% of a regular compound for the purpose of achieving a high level of fiber reinforcement to enhance tear resistance.

A great deal of the rubber industry is serviced by custom compounders who prepare materials for molders. TIRECYCLE® affords great opportunity to service the industry by providing custom compounds utilizing TIRECYCLE®. TIRECYCLE® takes on additional value when used as a compounding ingredient. In actual fact, the major competition to TIRECYCLE® is the compounder who tries to match TIRECYCLE® by alternative techniques in compounding. Integrating TIRECYCLE® and custom compounding is uniting product and service.

TIRECYCLE®, FIBRECYCLE™ and RRECYCLE™ are registered trademarks. TIRECYCLE® was judged to be unique and a patent was applied for. The United States Patent Office issued RRE patent number 4,481,335 on November 6, 1984. RRE is presently in the process of applying for several additional patents regarding developments in TIRECYCLE® technology. All patents are assigned to RRE.

TIRECYCLE® provides new properties to the thermoplastics polypropylene and polyethylene and polystyrene compounds. TIRECYCLE® is useful in the same way with polyvinyl chloride, polyesters, and urethanes. It has been estimated that as much as 150 pounds of TIRECYCLE® can be used per automobile in non tire applications. These are all new uses where rubber is not being used. In many respects the list of uses for TIRECYCLE® seems to be endless. The object is still to save at least 25% in cost with any application.

The TIRECYCLE® process has been thoroughly reviewed publicly. First of all it is a patented process, the first patent having been issued in November of 1984. In addition, no less than four Minnesota state agencies have examined it from the aspects of technical, economic and practical feasibility in connection with the financing for the first fully integrated TIRECYCLE® facility which is now under construction at Babbitt, Minnesota.

Just as important is the fact that it has been accepted in the market place. TIRECYCLE® has been marketed in limited volumes for the past four years utilizing the pilot plant facilities at our Minneapolis plant.

The only deterrent to full scale utilization has been our inability to produce the product in large quantities. The Babbitt plant will fill this void.

The Babbitt plant is designed to have a capacity of 60,000,000 lbs per year. This will require 3 - 4 million tires or a large portion of the scrap tires generated in Minnesota and Western Wisconsin.

However, the potential market for TIRECYCLE® is so great that at least four additional facilities of the Babbitt type will be needed within the next two - three years. As mentioned earlier the demand for the automotive industry alone will eventually require several plants. Conceivably there could be a TIRECYCLE® plant every 400 miles throughout the U.S. and this is our goal.

One of the interesting aspects of TIRECYCLE® is that it can prosper without as well as with governmental regulation or interference. As long as TIRECYCLE® provides the lowest cost for total disposal of scrap tires the discarded tires will be attracted. TIRECYCLE® simply pays its own way. In addition, TIRECYCLE® does not compete with the other methods of tire disposal mentioned at the outset and can prosper parallel with any tire disposal means.

"THE MARKET HIERARCHY OF RECYCLED TIRES"

By Timothy Baker
Baker Rubber Company
South Bend, Indiana

Presented to:
Fayetteville Technical Institute Continuing
Education No. Carolina Assoc. Of County Commissioners
and Cumberland County Clean Community Committee
November 13, 1986

Presented by:
Raymond Dzimian

"THE MARKET HIERARCHY OF RECYCLED TIRES"

Good morning, I'd like to thank the Fayetteville Technical Institute, The North Carolina Association of County Commissioners, The Cumberland County Clean Community Committee for inviting me to speak at the symposium.

This morning I'd like to continue to develop the relationship between the rubber recycling industry and the public sector. This relationship must take on new significance for our communities to economically control the scrap tire problem.

The major objectives of my paper are, one, to give you, a better background on traditional and existing methods of tire and rubber recycling. Two, I want to suggest that the solutions to tire and rubber recycling not in the collection of tires, nor in the development of processing methods--but in the development and expansion of existing markets for recycled rubber.

Three, I'd like to emphasize a significant degree of compatibility exists between the rubber recycling industry and the public sectors needs to dispose economically of our discarded tires.

I will cite several examples where we can work together to help resolve some of our problems, along with suggesting some interesting opportunities for all of us to consider.

The company I directly represent has been in rubber recycling for over 50 years, with a very hands-on, practical approach, and has been actively involved with the rubber recycling association and the Asphalt Rubber Processor Group since their inception.

I'd like to begin with a short, general overview of the rubber recycling industry as it stands today, and a historical perspective of this. This may prove beneficial to some, but may be common knowledge to others of you in the audience.

Since the end of World War II, rubber recycling has been on the decline. Prior to and during the early phases of World War II, 60% or more of the scrap tires generated in the United States were being recycled. When natural rubber supplies were cut off because of the war, a severe shortage of rubber was created. The rubber industry was almost completely dependent upon re-cycled rubber to fill their needs.

Because of these severe shortages and the strategic nature of rubber, our federal government became involved in the research and development of synthetic rubber.

How can this declining tire recycling trend be reversed? To answer this question, I think we first must try to explore the market hierarchy of recycled rubber.

If we look at the various markets for recycled rubber, we can see a clear differentiation in dollar value of the rubber that flows to these different markets, and the per pound cost to produce that rubber.

There is also a strong correlation between the net energy gain to the net dollar value of each application of a recycled tire.

In the hierarchy of tire recycling, the most economical use for a scrap tire, and the greatest net energy gain is to use the tire as a retread wherever possible. The reason is because recapping allows direct use of major portion of the tire. The problem is that there are limitations on the percentage of scrap tires that can be retreaded, which I'm sure this group is well aware of.

The next phase in the hierarchy of tire recycling is the use of scrap tires in the tire splitting process--and then finally die-cutting parts from the layers of rubber and fabric laminates to a specific design specification.

These parts include gaskets, seals, flexible spacers, suspension straps, elevator flights, dock bumpers, rubber rolls, floor mats and similar other products.

You may wonder why this is the second most valuable use of a scrap tire. The reason is that it leaves the tire in a condition closer to its original form than any other form of recycling other than retreading.

Also, if we compare tire casing material, to comparable virgin materials--the cost energy necessary to produce the tire casing material is only a fraction of the virgin material cost.

You have now heard the positive aspects of tire splitting, of the tire splitting industry. The negative aspect is that the tire splitting industry has been in existence for over 50 years, and at present is only using approximately one percent of the scrap tires being generated in the United States.

The tire splitting industry faces a variety of positive and negative factors. Because of the escalating raw material costs of virgin rubber, the splitting industry is putting forth more effort to expand and develop new applications for new uses of tire material.

In the latter part of World War II, and shortly thereafter, synthetic rubber came into widespread use. Its penetration of the total rubber supply continued to grow throughout the fifties and sixties. This was basically a result of low petroleum prices.

Synthetic rubber usage continued to grow until the early 1970's when the Arab oil embargo awakened us to a very serious situation, and rubber recycling began to take on a new meaning.

Surprising, over the last ten years little or no progress has been made in amounts of rubber that are being recycled. There has been a bit of conversation concerning recycling rubber from many segments of the rubber industry and from governmental agencies, but little actual programs has been made. Over the last year, because of sharply falling oil prices, certain segments of the Rubber Recycling Industry have fallen on severely hard times.

In the early 1950's, the recycling industry produced approximately 350,000 tons of product per year. This represented 22% of the total rubber consumed in the United States at that time.

In 1980--by contrast-- only 120,000 tons of recycled rubber were produced, and this represented only three and a half percent of the total rubber consumed in the United States during that year.

These figures are published by the Department of Commerce.

So what has all this meant to the recycling industry? One point of interest is that almost every major tire manufacturer at one point has a recycling facility as part of their standard operation. But today, only one tire company is directly involved in rubber recycling.

Also, the demand for reclaim produced by independent reclaimers declined steadily over the past 30 years. The rubber grinding industry--and I believe this fact is very, very important--is the newest segment of the rubber recycling industry, and has been developing to accommodate the anticipated demand for recycled rubber because of the dramatic price increase of petroleum products, specifically synthetic rubber, since the early 1970's.

But--as this industry has developed, its capacity has far exceeded the market demand for the product--and the rubber grinding industry at this point is operating significantly below capacity.

On the other hand, some of the major traditional applications for tire material in the automotive and farm implement industry are very depressed at this time. Also, over the long term the tire splitting industry faces the probable of availability of supply on new-steel belted tires.

The overall, long term outlook for the use of scrap tires, as die-cut parts, looks steady, with some slow growth possible over the next five years.

Continuing with the hierarchy of tire recycling, the third most energy-efficient and economically beneficial use of scrap tires will lead us to ground rubber, which is used in a variety of applications. The use of ground rubber can very from being a high grade filler, used in tires and some molded products, to a binding material in certain applications, to a resilient aggregate in athletic surfaces, to an additive to asphalt.

In my opinion, the concept of using ground rubber to displace or increase the effectiveness of petro-chemical products has the potential to consume the greatest percentage of scrap tires with optimum economic gain.

I base my opinion on the potential future growth of the asphalt rubber market, and several other markets in the ground rubber area.

I would like, after completing the hierarchy of recycling, to discuss the asphalt rubber market in more detail.

The other markets of ground rubber do have significant potential growth, but not to the extent that the asphalt rubber market does.

These markets have a successful past history, and appear to have a good future for utilizing scrap tires. Of the three remaining markets, the use of ground rubber as a filler for the molded rubber industry appears to have the brightest future.

Much more technical research and development, as well as marketing work, must be done before significant growth can take place in this area.

The fourth area in the hierarchy of tire recycling is the rubber reclaiming industry. This process consists of size reduction of the tire through grinding, shredding or pulverizing, submission of the material to heat and chemical agents, whereby a substantial devulcanization or regeneration of the rubber compound takes place. This causes the rubber then to revert to its original plastic state.

This industry is the oldest--and until recent times, far and away, the largest--segment of the rubber recycling industry. Its volume has continued to shrink over the last 30 years, as I discussed earlier in my paper.

The future success of the reclaim industry hinges on the acceptance of ground rubber, since ground rubber in many cases is in direct competition with reclaim--and the ability of the reclaim industry to find new uses and new methods of using their products, as well as its ability to compete with virgin materials.

The fifth major area in the hierarchy of tire recycling is the use of tires in direct energy recovery through incineration. If you remember, the hierarchy I am describing is based upon the economical use of tires and the net energy gain by using these scrap tires.

If we compare the net energy gain of incineration to the other markets for recycled rubber, we quickly see that the net energy gain is significantly lower than the other markets. This is a significant disadvantage.

But there is a major advantage for incineration for direct energy recovery--and that is that this concept is practical and viable today.

The success of this use of scrap tires hinges on the continued development of size reduction equipment and performance of marketing work that must be done to develop this area.

I see the incineration for energy recovery as the base that all rubber recycling can be built on. It is not the best use of a tire, but it is a base that can be used to develop the other markets that I have been discussing.

There are several tested and existing incineration projects that have and are functioning successfully today. These range from the burning of whole tires in cement kilns to co-firing a shredded rubber with wood chips and/or coal in several locations in the United States and Europe.

The hierarchy of tire recycling can be extended to some fringe uses of scrap tires, such as artificial reefs where the tire makes a surface for encrusting organisms essential for the food chain for fish, breakwaters where the tires are latched together to use along shore lines to prevent erosion, crash barriers along bridges, piers and highway abuttments.

These uses, although advantageous in themselves, have a very limited ability to consume any significant volumes of tires in a practical manner.

I have now completed the hierarchy of tire recycling as I see it existing in the United States today. I have included only the established rubber recycling industries and the existing markets for recycled rubber.

There are many instances in which we have read or heard of new processes and new technologies that claim to have the capabilities of using great volumes of scrap tires. These may at some time fit into the hierarchy of tire recycling but at present, because of a lack of existing practical application, I have not included them in the hierarchy I am describing.

Now I'd like to focus on the use of rubber in asphalt, which is the area I believe has the greatest potential for consuming large percentages of scrap tires in a sound economical and energy efficient manner.

The use of rubber and asphalt is not a new concept. Preliminary work for adding varying amounts of rubber to asphalt was done over 35 years ago.

In the past 20 years, the use of asphalt rubber has been developed on a commercial basis. The general term, "asphalt rubber" has been applied to a variety of products. All asphalt rubber products contain a mixture of asphalt and rubber, and many times a dillutent or extender oil.

The type of asphalt use varies, as does the amount of oil in quantity and grade of rubber. Normally an asphalt product is manufactured by reacting a minimum of 20% of rubber derived from scrap tires, with hot asphalt, over differing periods of time.

These asphalt rubber blends are tailored to produce specific properties that are considered critical to improving performance in a given application. These improved properties come in the form of higher degrees of elasticity and resilience, designed to retard reflective cracking and improving adhesion properties. Also, the addition of rubber to asphalt results in improved temperature susceptibility, which improves the cold temperature characteristics of asphalt.

The uses of asphalt rubber are varied. In road construction, the typical applications are as a stress absorbing membrane, surface treatment or inner layer.

Asphalt rubber can be used in hot mix applications, both of open and dense graded designs. One of the most effective-- uses of asphalt rubber is a crack and joint filler in pavements.

Additional applications, other than road uses, have also been exceptionally well received. Asphalt rubber has been used in water retention liners in ponds. Asphalt rubber has also been used to line the bottoms of land fill sites, and as a cover over landfill areas containing semi toxic materials. An additional use of asphalt rubber which is still in the developmental stages is as a roofing material.

Asphalt rubber is not without its problems. To prove the effectiveness of asphalt rubber, a job must be in place and perform satisfactorily for several years. This makes the marketing of asphalt rubber, which in many cases is perceived as a new product--a lengthy project.

Also, asphalt rubber in many cases has a higher front end cost than traditional asphalts. But this is offset by significantly lower lifetime costs in most situations.

The higher front end costs, along with very tight highway maintenance budgets across the United States, adds to the difficulty marketing asphalt rubber.

Even with these difficulties, the interest in asphalt rubber has been growing. In October of 1981, the FHWA sponsored an asphalt rubber symposium in San Antonio, Texas. Over 250 persons from 30 states and several foreign countries attended this symposium. Out of this grew an Association of Rubber Suppliers and Asphalt Rubber Producers.

The Asphalt Rubber Producers Group is actively involved in general promotions of asphalt rubber. The Asphalt Rubber Producers Group believes that with support of the public sector there is strong potential for developing asphalt rubber to the extent that it will use a very high percentage of all scrap tires generated annually.

This can be done in an energy efficient and economical manner.

In conclusion, if we look at the state of the tire recycling industry, which presently continues less than 4% of the nation's scrap tires, and look at the cost (80 million dollars) of having to dispose of 200 million plus passenger and truck tires. It then seems obvious to me that the rubber recycling industry and the public sector have a lot to gain by working together.

As stated earlier, I firmly believe the development of recycled rubber markets, not the collection and processing procedures, is the area that we must focus on as a group if we are to have some significant impact on the amount of tires that are to be recycled.

Further, I believe, we must support existing markets and existing concepts, for it is these areas that there is a much higher probability of success.

I propose to you that as a group, we concentrate on and give our support to the proven economic uses of recycled rubber. Without this support, and without working together, we will continue to have to be satisfied with the status quo.

TIRE-DERIVED FUEL/RESOURCE RECOVERY SYSTEMS

Robert H. Herrmann

NATIONAL ECOLOGY, INC.
16 Greenmeadow Drive
Timonium, Maryland 21093

Presented at Scrap Tire Recycling and Vendors Workshop

Sponsored by Fayettville Technical Institute
North Carolina Association of County Commissioners
and Cumberland County Clean Community Committee

Fayetteville, N.C.
November 13, 1986

ADVANTAGES OF
TDF/RESOURCE RECOVERY SYSTEMS

- ONE SYSTEM DISPOSES OF BOTH MSW AND TIRES BY BURNING IN RDF BOILERS

- SINCE TDF GENERALLY REPRESENTS ONLY 1 TO 2 PERCENT OF WASTE STREAM IT HAS NEGLIGIBLE IMPACT ON BOILER OPERATION AND EMISSIONS.

- TDF INCREASES STEAM OUTPUT OF BOILER

- CIRCULATING FLUIDIZED BED BOILERS CAN BURN LARGE AMOUNTS OF TDF WITH RDF.

ECONOMIC CONSIDERATIONS

- ENERGY RECOVERY OF VARIOUS FUELS
- ESTIMATED VALUE OF STEAM FROM TDF
- ACQUISITION COST OF TIRES
- TYPE OF BOILER AND POLLUTION CONTROLS REQUIRED
- COST OF SHREDDING TIRES

ENERGY RECOVERY OF VARIOUS FUELS

APPROXIMATE HEAT VALUE AND STEAM OUTPUT

	BTU/LB.	LBS. STEAM/ TON FUEL
COMBUSTION OF TIRES	15,000	22,000
OIL	18,500	27,000
PLASTIC	15,000	22,000
PYROLYSIS OF TIRES (FUEL PRODUCTS ONLY)	11,000 - 14,000	16,000 - 21,000
COAL	11,000 - 13,000	16,000 - 21,000
REFUSE DERIVED FUEL (RDF)	5,500 - 6,500	7,500 - 8,900

ESTIMATED VALUE OF STEAM FROM TIRES

PRICE OF STEAM, $/M LB.	6	8	10
VALUE OF STEAM FROM 1 TON TIRES, $	132	176	220
VALUE OF STEAM FROM 100 TONS TIRES, $	13,200	17,600	22,000
VALUE OF STEAM BASIS 100 TONS TIRES/DAY, FIVE DAYS/WEEK, 50 WEEKS/YEAR	$ 3,300,000	4,400,000	5,500,000

ACQUISITION COST OF SCRAP TIRES

- VARIES WITH LOCATION AND QUANTITY OF TIRES REQUIRED

- ASSUME APPROXIMATELY 1 SCRAP TIRE PER CAPITA PER YEAR

- ACQUISITION COST FOR TIRES CAN BE ZERO OR LESS. A DISPOSAL FEE OF $20 TO $60/TON CAN BE CHARGED, BUT MAY BE OFFSET BY HAULING COSTS IF HAULING IS REQUIRED.

- HAUL DISTANCE IS IMPORTANT. HAULING 200 TO 300 MILES MAY RESULT IN A $10 TO $20/TON ACQUISITION COST.

TYPES OF BOILERS

- TRAVELLING GRATE DEDICATED RDF BOILER

- CIRCULATING FLUIDIZED BED BOILER

- PYROLYSIS SYSTEM - PRODUCES
  - GAS
  - OIL
  - COMBUSTIBLE CHAR

Travelling Gate for burning RDF or TDF

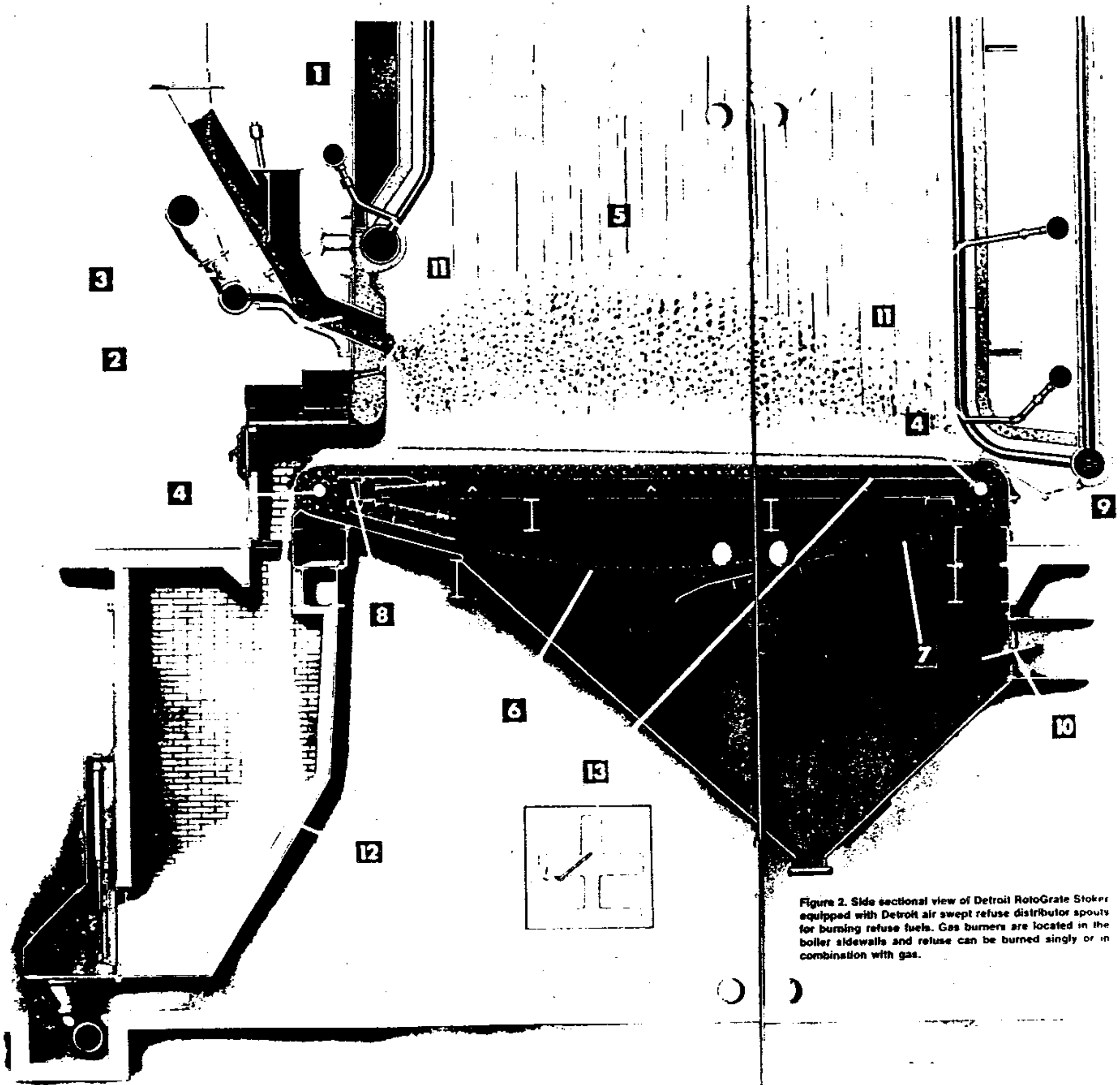


Figure 2. Side sectional view of Detroit RotoGrate Stoker equipped with Detroit air swept refuse distributor spouts for burning refuse fuels. Gas burners are located in the boiler sidewalls and refuse can be burned singly or in combination with gas.

Important features

1 **Balanced Damper Assembly** The inlet of each air swept refuse distributor spout is equipped with a balanced damper assembly which contains a counterweighted damper whose purpose is (a) to reduce the velocity of refuse before entering the air swept spout. (b) distribute the flow of refuse across the width of each spout. (c) prevent fire flashback up through the spout in case of furnace pulsations and (d) prevent infiltration of air into the furnace when no refuse is being burned.

2 **Detroit Air Swept Refuse Fuel Distributor Spouts** Are available in various widths to permit the best combination of feeder size and number of feeders for uniform fuel distribution in any furnace width. They utilize a curtain of air which sweeps the floor of the spouts and floats fine and light density refuse fuel well into the furnace.

3 **Motorized Rotary Air Dampers** Control the air to each air swept refuse fuel distributor spout by alternately increasing and decreasing both quantity and pressure of the air in several cycles per minute assuring even fuel distribution from front to rear of furnace.

4 **Front and Rear Grate Shafts** Carry the grate chains on hardened sprockets and a bearing is located at each side of each row of grates.

5 **Grates** Are specially designed for spreader stoker firing. Unique hinged grate bar design permits the individual grate bars to open at the lower portion of the catenary facilitating air admission to the fuel bed and to discharge any siftings that may accumulate on the lower strand.

6 **Catenary Design** provides automatic take-up or tensioning of grate chains to prevent jamming.

7 **Rear Slide Rail** Is adjustable so that effective catenary is maintained.

8 **Automatic Under Grate Air Seal** Are ruggedly constructed and self-adjusting. A Detroit RotoGrate exclusive.

9 **Air Seals** Are provided at rear and each side of the stoker preventing air infiltration.

10 **Blast Gate** Positioned to assure uniform air pressure distribution in the plenum.

11 **High Pressure Over Fire Air Jets** Strategically located, provide turbulence and thorough mixing of the volatile matter and air to assure complete combustion.

12 **Ash Storage Hopper** Ash is automatically discharged to the ash storage hopper and periodically removed to the ash removal system.

13 **Thermocouple Assemblies** Are attached to stoker top support rails to accurately measure temperature of grate castings. If grate temperature exceeds safe limits, operating personnel can act promptly to make necessary operational changes to keep grate temperature within safe limits, assuring long grate life.

Fuel Flexibility

Götaverken CFBs burn a wide variety of fuels including coals ranging from anthracite to lignite, biomass, sludge, peat, bagasse and RDF (Refuse Derived Fuel).

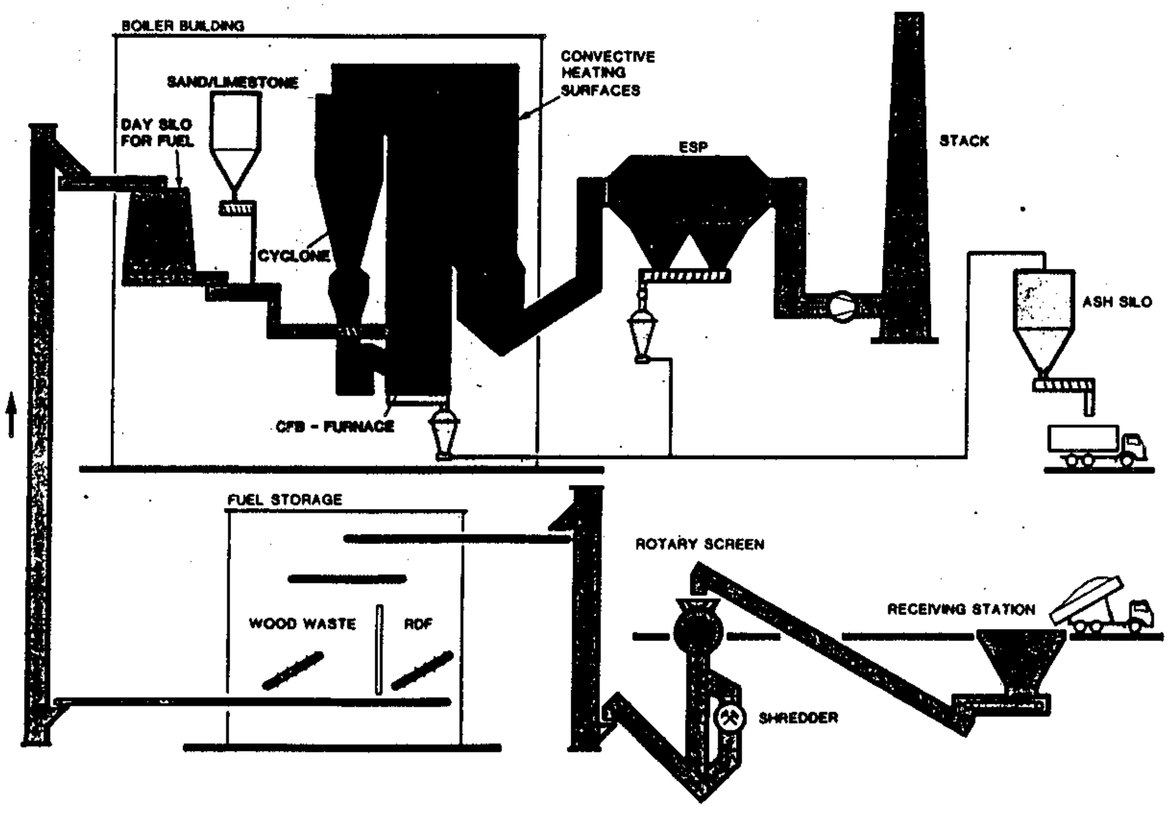
Fuels are burned alone or in combination. This permits flexibility in selecting the most economical fuel source without physical changes to the unit.
High sulfur coals are burned meeting code compliance without the addition of an SO_2 scrubber. Desulfurization is accomplished by feeding limestone with the fuel.

Low ash fusion temperature coals and peat are burned without slagging or clinkering because the CFB operates at temperatures well below the ash melting point.

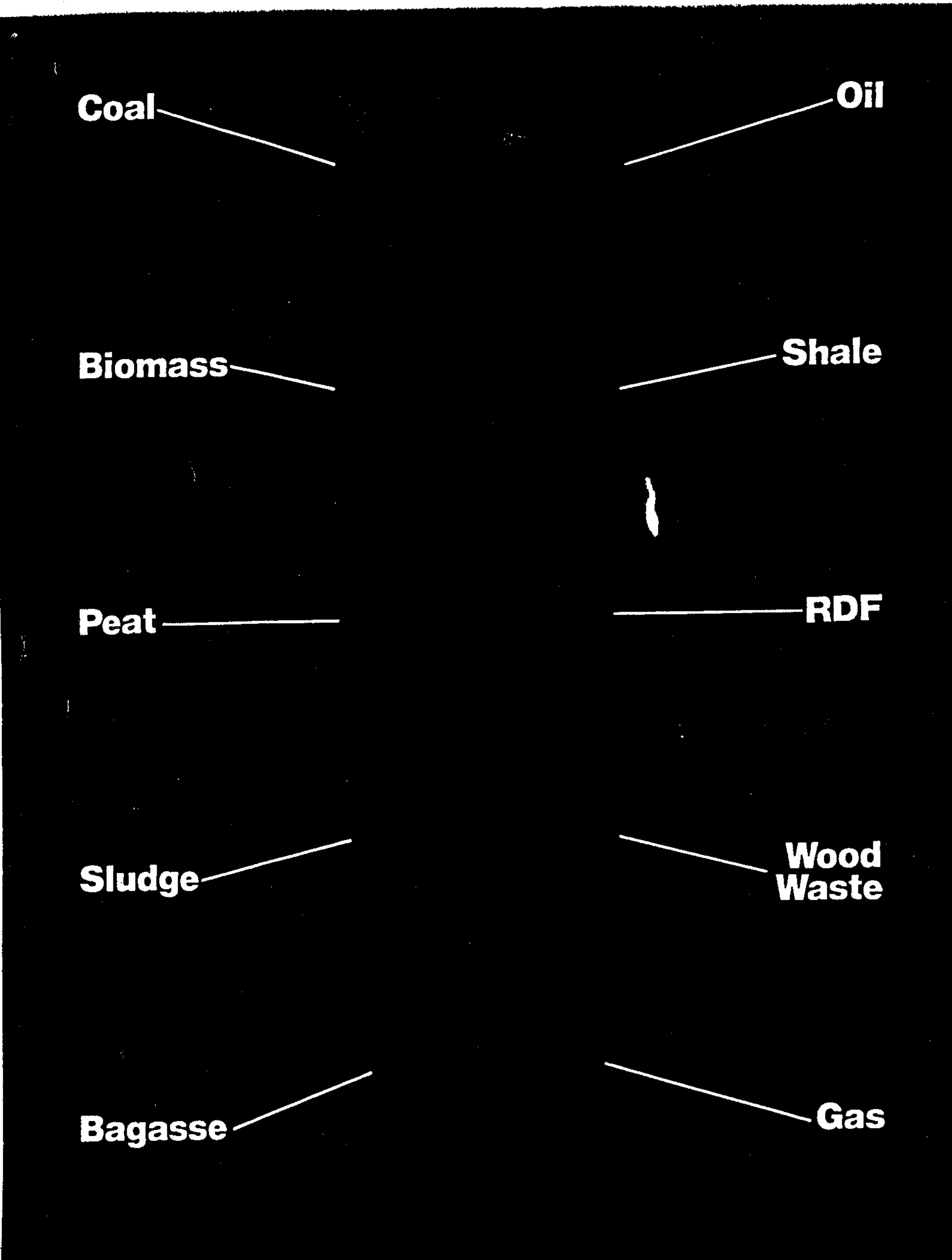
High ash fuels are ideal for CFBs since the inherent ash forms the inert bed material.

RDF is burned successfully because good mixing prevents formation of stratified pockets of incomplete combustion.

High moisture fuels are burned without difficulty since there is a large reservoir of heat to dry the wet incoming fuel.



CFB Turnkey Boiler Plant Burning RDF/Wood Waste/Peat, Sundsvall, Sweden


Coal
Oil
Biomass
Shale
Peat
RDF
Sludge
Wood Waste
Bagasse
Gas

TIRE SHREDDERS

- SLOW SPEED SHEAR MILL
- BOILERS REQUIRE APPROXIMATELY 2 INCH x 2 INCH SIZE
- ESTIMATED COST OF SHREDDING TO 2 INCH x 2 INCH SIZE:
  $15 TO $20/TON

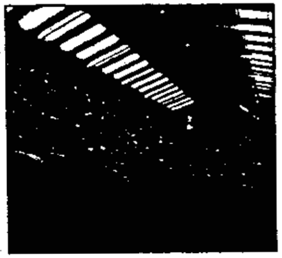
AN ABC OF TYRE TRANSFORMATION.

A FEED STORAGE AND LOADING.

The tyres (up to 1.75 metres diameter) are fed via front-end loader and fixed crane. The double rotor knife mill shreds tyres and associated matter. The product is sized to give a nominal 8" maximum in a rotary screen.

Output is then weighed and conveyed to the top of the reactor in 240kg batches and fed into the reactor lock hoppers. (Oversize shred is re-cycled back to the mill for further reduction.)

A buffer stock equivalent to four days throughput alleviates any maintenance difficulties.



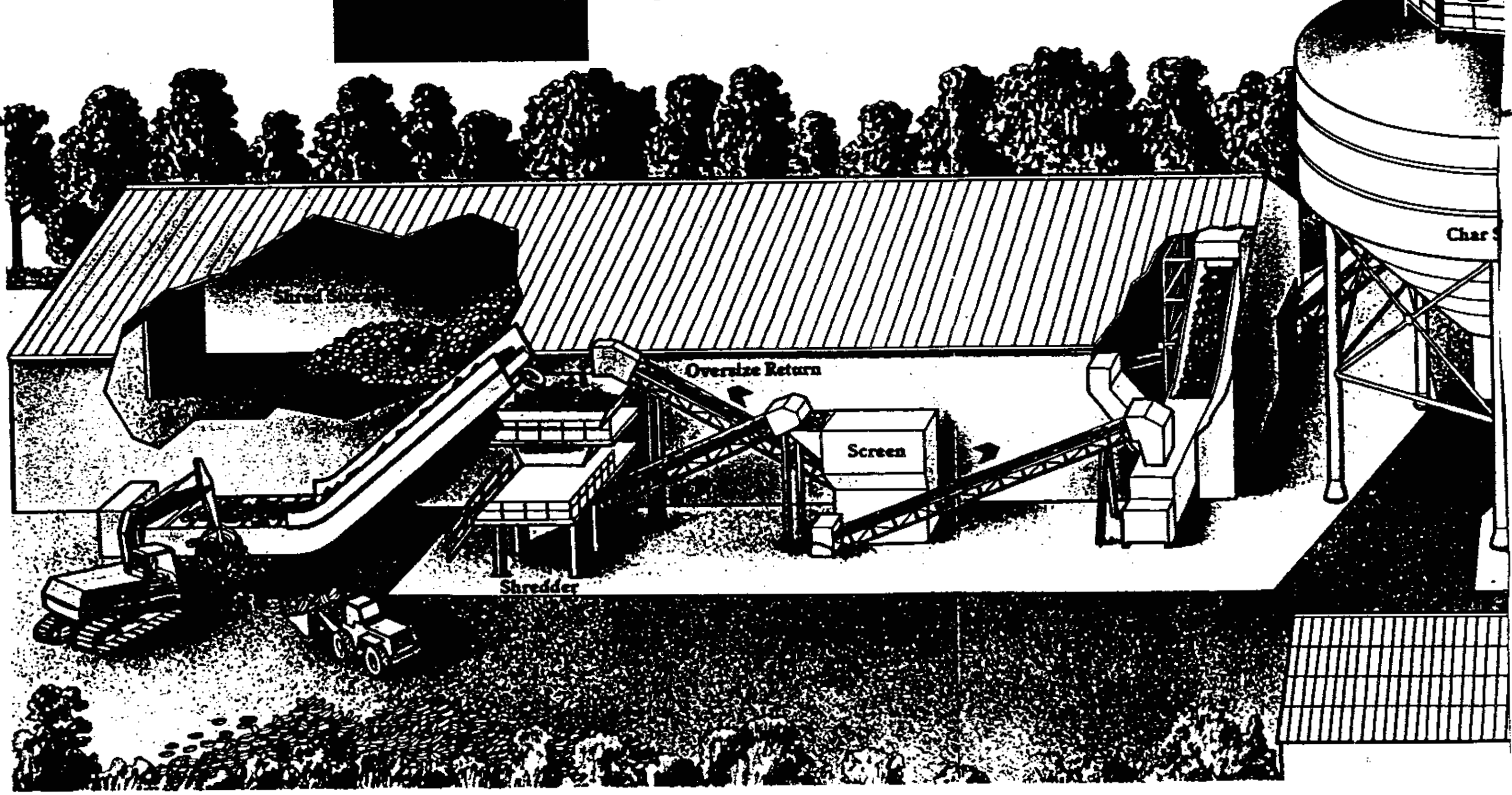
B REACTOR, OIL AND GAS PROCESS LOOPS.

The shredded tyres enter the reactor via a purged triple valve, double chamber sealing system. Hot, oxygen-free gases pass through the bed of tyres in a counter-current fashion causing pyrolysis to occur. The hot gases, now supplemented by pyrolysis product oil in the vapour phase, leave the reactor through a short overhead line, and enter the line quench where they meet a spray of cold oil. The vapourised product oil condenses, and all oil is collected in the base of the primary quench tower. After initial filtering, the flash point is adjusted before further filtering, cooling and pumping to storage.

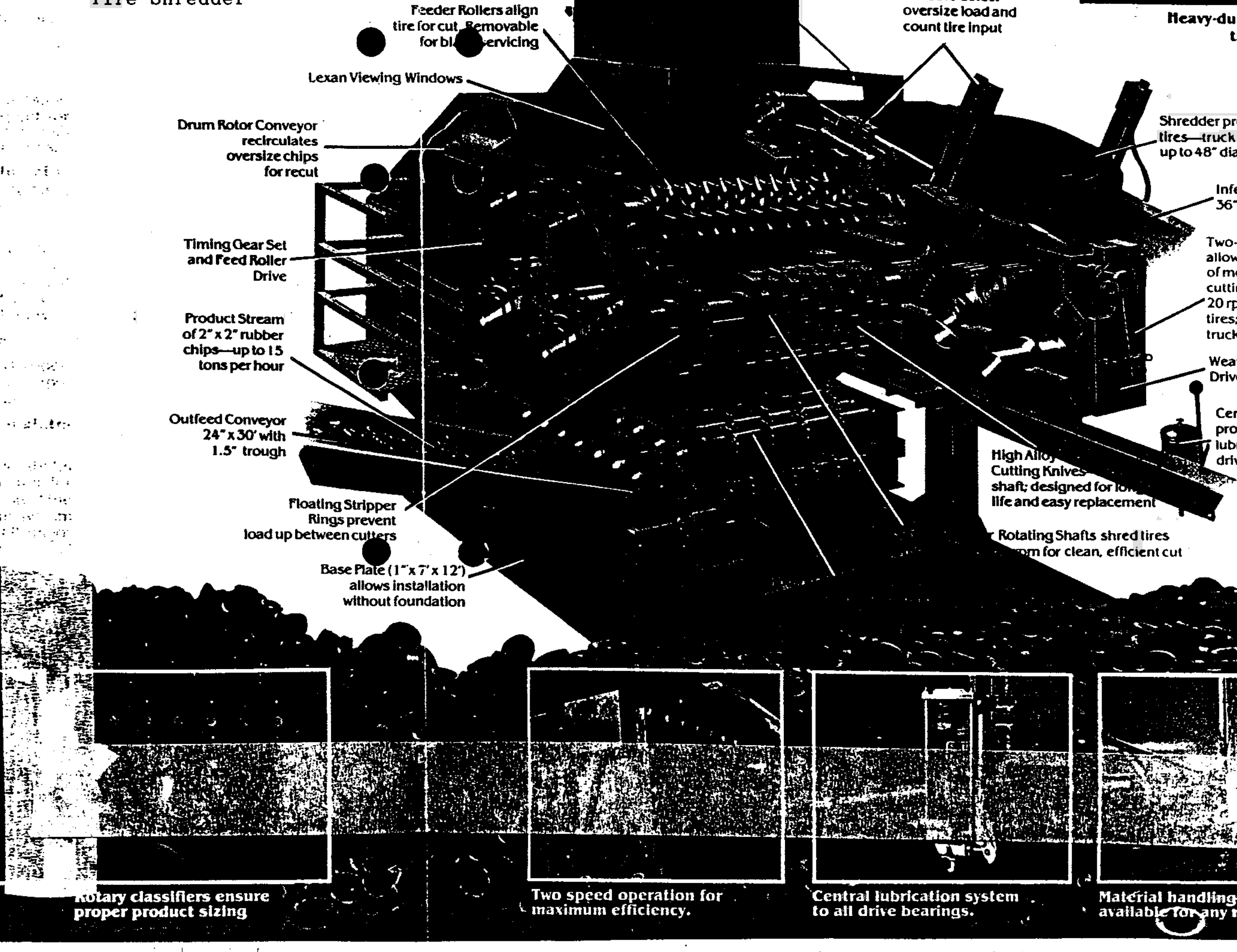
Gases come overhead from the quench tower at approximately 90 degrees C. They contain light ends and water in the vapour phase which are condensed in the overhead condenser, and collect in the decanter where lights and water are separated.

Clean gases from the decanter pass through a knock-out drum into the recycle blower. They are then either used for steam raising or as the priority fuel for the fired heater, or they pass through the tubes of the heater and back into the reactor.

Solids (friable carbonaceous char and lengths of steel wire) are removed from the reactor bed by large inclined screws. They then fall by gravity into hollow flight screws to be cooled to below the ignition point of the char. A final screw conveyor feeds them into a purged triple valve, double chamber lock hopper system, from which they leave the reactor atmosphere.



Tire Shredder

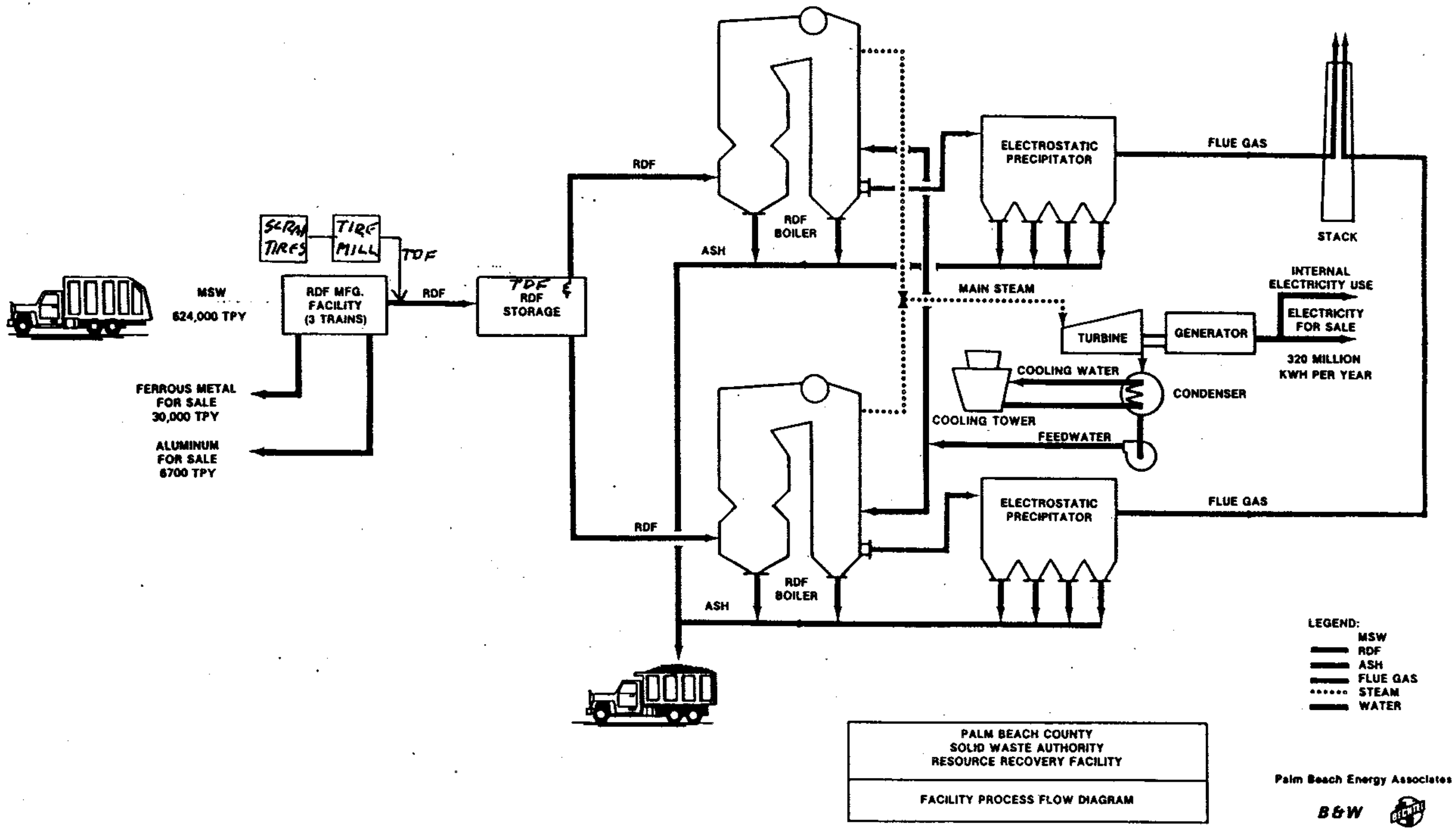


TYPICAL

TIRE-DERIVED FUEL/RESOURCE RECOVERY SYSTEMS

	TONS PER DAY	
	MSW	TIRES
• AKRON, OHIO	800	11 (80 MAX)
• PALM BEACH COUNTY, FLORIDA	2,000	20-40
• COLLIER COUNTY, FLORIDA	850	250 MAX
• ERIE, PA.	850	250 MAX

Process Flow Sheet for Burning RDF & TDF



ENVIRONMENTAL ASPECTS

- TIRES HAVE APPROXIMATELY 1% SULPHUR (LESS THAN MOST COALS ON A HEAT BASIS).
- SULPHUR EMISSIONS NEGLIGIBLE IF TDF IS ONLY 1 TO 2% OF FUEL
- SULPHUR EMISSIONS CAN BE REDUCED TO EPA STANDARDS BY USE OF
  - DRY SCRUBBERS OR
  - CIRCULATING FLUIDIZED BED, OR
  - BOTH

ater in the vapour phase which
sed in the overhead condenser,
in the decanter where lights
re separated.
ean gases from the decanter
h a knock-out drum into the
ver. They are then either used
ising or as the priority fuel for
ter, or they pass through the
heater and back into

lids (friable carbonaceous char
of steel wire) are removed from
ped by large inclined screws.
ll by gravity into hollow flight
cooled to below the ignition
char. A final screw conveyor
into a purged triple valve,
mber lock hopper system, from
leave the reactor atmosphere.

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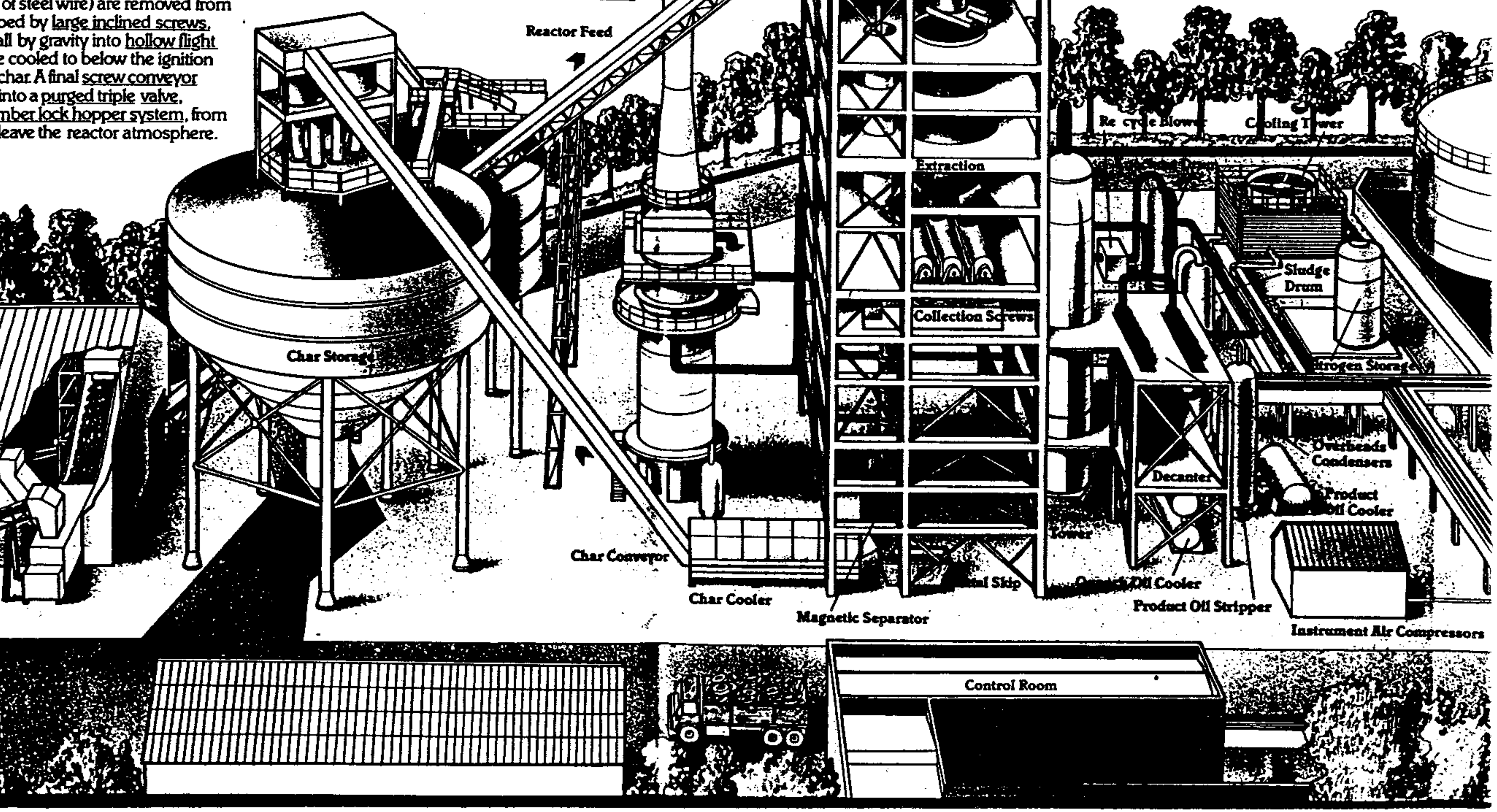

SUMMARY

- ONE SYSTEM CAN DISPOSE OF BOTH MSW AND TIRES
- TDF PAYS FOR ITSELF IN STEAM GENERATED
- TDF BURNS WELL IN STATE-OF-THE-ART BOILERS
- SULPHUR EMISSIONS ARE INSIGNIFICANT AT LOW PERCENTAGES OF TDF AND CAN BE READILY CONTROLLED AT HIGHER PERCENTAGES.

Prepared for
Fayetteville Technical Institute
November 1986

MUNICIPAL USE OF ASPHALT-RUBBER

BY

RUSSELL H. SCHNORMEIER

MUNICIPAL USE OF ASPHALT-RUBBER

BACKGROUND

The idea of using ground rubber in hot asphalt was first conceived by Mr. Charles McDonald in the early 1930's. As Materials Engineer with the City of Phoenix in 1969, Mr. McDonald had the opportunity to experimentally develop his ideas for a new paving material. While performing the initial experiments in the development of asphalt-rubber as a viable paving material, McDonald convinced the local industry to try it on the street. So began the history of asphalt-rubber in Phoenix.

The first use of asphalt-rubber on a city street was as a seal. The new asphalt-rubber was applied followed by a chip cover. This application became known as a stress absorbing membrane or SAM.

The early applications of asphalt-rubber were marked by some failures, as was to be expected. Improvements in equipment and mix designs over the past 18 years have now virtually eliminated failures. Observation of applications in Phoenix over time has helped in the development of asphalt-rubber application techniques. Applications which would be classified as failures have been of interest due to, 1) The lessons learned in regard to composition and application methods, and 2) The "forgiving" nature of this material. Pavements which exhibited early cracking with asphalt-rubber were found to deteriorate much more slowly than standard pavements. In some cases, time improved the pavement condition, as the asphalt-rubber flexed and worked with the pavement stresses. Asphalt-Rubber maintains pavement viscosity at near original levels. Standard asphalt hardens much more rapidly, becoming brittle as volatile components are lost.

Advancements made in the mechanics of application have greatly improved the quality of asphalt-rubber pavements over the years. In the 1981 national seminar on asphalt-rubber, specifications for Asphalt-Rubber Application developed by the City of Phoenix were adopted. Experience gained through years of experimentation have been incorporated into these specifications.

TYPES OF APPLICATION

Since 1968 Phoenix has placed over 700 lane miles of asphalt-rubber stress absorbent membrane (SAM). This method consists of the application of 0.6 gallons per square yard of hot asphalt-rubber directly on an existing stressed surface. A pre-coated cover aggregate at a rate of 25-30 pounds per square yard follows the asphalt-rubber. This application is used on streets with up to 55,000 ADT and was also used on Sky Harbor Airport in Phoenix.

In 1972 the City designed an economical residential street section. The pavement consisted of 4 1/2 inches of soil cement with 1 1/2 inches of asphaltic concrete followed by asphalt-rubber. This type of design was used from 1972 to 1974. There still are 37 miles of this design in use. The original design, intended to last five years, has lasted 14 years. Although, this type of design did not stop reflective cracking from the soil cement after eight years, with proper maintenance such as a chip seal, or another asphalt rubber application, this pavement should last for 20 years or more.

Perhaps the most astonishing pavement the City of Phoenix has is where asphalt rubber was applied directly on native soil. This pavement is now 16 years old with only two chip seals in the last 12 years. The last traffic count was 7,400 ADT. The pavement is just now failing and in need of reconstruction.

In 1982, a double application of asphalt-rubber on a major street was constructed. The total application rate was 1.25 gallons per square yard over an existing street. The existing surface was an asphaltic concrete roadway with portland cement concrete parking area. The street contained the remains of a street car track, including ties. The surface had up to two-inch cracks in the concrete with 1/4" to 1/2" crack throughout the roadway. This pavement was overlayed in 1983 to improve the ride. This type of design became known as a stress absorbant membrane interlayer (SAMI). The original pavement cracks have not reflected through except where the two-inch cracks existed in the concrete. These are indicated by hair line cracks only.

Phoenix has used asphalt-rubber in other ways that have created new industry and business. A partial listing follows:

1. Subgrade seal to retain a constant moisture content in swelling soils.
2. Crack filling prior to chip sealing, slurry sealing, and/or overlays.
3. Joint filler for portland cement concrete pavements.
4. Lake liners in parks and industry.
5. Roofing.

THE LATEST IN CITY STREET DESIGN USING ASPHALT-RUBBER

Today asphalt-rubber is being used as a SAMI for reconstruction of our major streets. As the city grew, it incorporated several miles of two lane roadways. To maintain the traffic demand these streets had to be widened from two to six lanes. The existing pavement was structurally adequate with an overlay. It was elected to keep the existing paved section by paving on each side to obtain the desired width. An asphalt rubber SAMI was then placed, followed by an overlay to obtain the desired grade and ride.

The SAMI system has saved materials, reduced utility relocations, and reduced inconvenience to the public. The current cost saving is estimated to be $250,000 to $300,000 per mile of major street.

The design of major streets requires alternatives that fit both the condition of the project and the politics. One of the design alternatives is to use a cement treated base followed by an aggregate base followed by asphaltic concrete. The intent of the aggregate base is to serve as a zone for crack absorption between the cement treated base and the surface. Also, the aggregate base serves as a curing blanket for the cement treated base when immediately applied.

Asphalt-rubber has been recently utilized in place of the aggregate base. The asphalt-rubber is applied to the cement treated base, serving as a curing cover and retarding reflective cracking from the base. The asphalt-rubber is applied at the rate 0.75 gallon per square yard followed by chips. The chips allow traffic and prevent the pickup of the asphalt-rubber during construction. This system has saved $10,000 per mile in materials alone, with additional savings from decreased utility relocations.

New portland cement concrete pavements have been overlayed with double applications of asphalt-rubber due to early cracking in the concrete. The cracks have not reflected through to date. This is not a recommended practice, however, the contractor lost the concrete while constructing it. The more he tried to save it, the more the pavement cracked.

Asphalt-rubber as a binder in asphaltic concrete has been placed on a city street. This concept was first tried in 1971 with questionable success. The Arizona Department of Transportation (ADOT) has used asphalt-rubber as a binder on surface materials with reasonable success. The City's most recent trial was in 1985 wherein 13% asphalt-rubber binder was used with a coarse graded aggregate. This segment was placed on a super elevated section. The super elevated section was developed by placing one-inch of A-R AC on the lower side with five-inches on the upper. This experiment offered the opportunity to observe how the variable thickness performed. The three to five-inch section was found to be unstable under high ambient temperatures. The less than two-inch section is performing very well.

After observing the performance under construction it was concluded that the AR-AC binder should be reduced to 9%. In addition, a maximum placement of two-inches is recommended. This design will be continually observed and reported on.

The reasons for selecting asphalt-rubber are the same as for selecting a standard seal:

1. Provides a low-cost all weather surface.
2. Waterproof paving.
3. Provides skid-resistant surface.
4. Gives new life to dry, weathered surfaces.
5. Reinforces pavement strength.
6. Guides traffic.
7. Improves visibility.

The asphalt-rubber, however, offers these added advantages:

1. Prevents crack reflection
2. Prevents spalling.
3. Provides a truly flexible surface.
4. Reduces maintenance for at least eight full years.
5. Increases life of pavement by a factor as large as two.
6. Delays need for reconstruction.

Asphalt-rubber was not considered a preventive maintenance material in new construction until the reported work done at Sky Harbor International airport. The asphalt-rubber sealed runway preserved the viscosity of the pavement and maintained much of the original flexibility of the asphalt-concrete, (refer to Figure1). This property adds a major advantage in the use of asphalt-rubber in new construction.

ECONOMICS

Does asphalt-rubber save money, time and inconvenience? Considering the additional pavement life gained by applying asphalt-rubber, the reduction of utility relocation and pavement sections, and the added in convenience to the public, yes. When asphalt-rubber was first used in 1969, the cost was three times that of a conventional asphalt. Today the cost is 1.5 times conventional asphalt in Phoenix. Figure 2 shows the costs comparisons for standard and asphalt-rubber chip seals in the past 15 years in Phoenix.

It must be pointed out that asphalt-rubber has historically been applied in situations where pavement reconstruction was indicated, but was not economically possible.It is difficult to measure the cost savings in maintenance alone. The hours spent on an asphalt-rubber treated surface has been minimal to non-existant.

Figure 3 shows the savings obtained by using asphalt-rubber instead of a standard chip seal. Maintenance costs are added to both seals which start with only their 1975 placement costs. While the asphalt-rubber shows only a slight increase due to maintenance starting in 1983, the standard chip seal has already been resurfaced in 1983. This second chip seal, combined with maintenance prior to the resurfacing, more than triples the initial cost.

Asphalt-rubber has given the engineer property values that have been proven in municipal work by:

1. Stopping reflective cracking in pavements with less than 0.25 inch (0.64 cm) cracks for over 3 to 12 years.
2. Stopping spalling of asphaltic concrete around pot holes and larger cracks.
3. Water-proofing the structure to obtain maximum stability.
4. Sealing and preserving the original quality of the asphalt cement and the asphaltic concrete pavement.
5. Reducing maintenance due to all of the above.
6. Sealing the subgrade to minimize the volume changes that take place due to moisture changes.
7. Serving as a stress absorbing interlayer to reduce future maintenance.
8. Offering a flexible property for streets and roads.
9. Performing as an excellent crack-filling material and joint sealer.

CONCLUSION:

Asphalt-rubber has performed very well in Phoenix. Several of the original installations in the past 15 years are still working. As pointed out asphalt-rubber was used in severe cases of disrepair and managed to save the roadway from major maintenance costs and reconstruction. The Material has delayed reconstruction by as much as 15 years.

The City of Phoenix is currently using asphalt-rubber for all crack filling. Over 20 miles of SAMI's have been completed with an average annual future use of ten miles per year. Over 500 lane miles of SAM's have been placed with an average future annual usage of 25 miles per year.

The municipalities surrounding Phoenix are using asphalt-rubber for maintenance along with the counties and the State of Arizona (ADOT). Asphalt-Rubber is no longer considered experimental, it is being used as a problem solving material. However there are experiments that are on going in using asphalt-rubber as reported here. We believe in keeping an open mind to any and all applications of asphalt-rubber. It is not a cure-all and needs engineering judgement for a successfull application.

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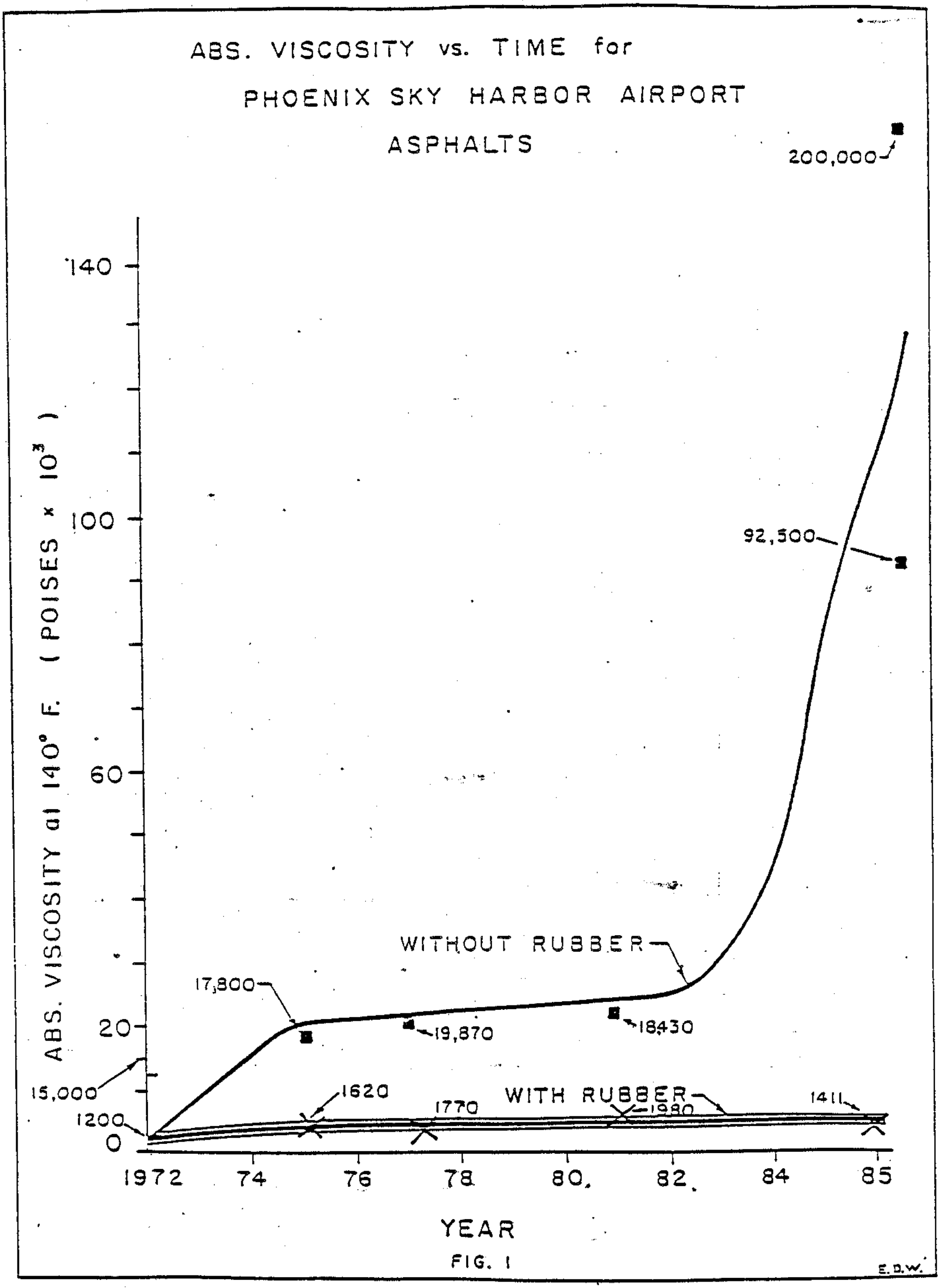


Absolute Viscosity vs Time for Phoenix Sky Harbor Airport Asphalts

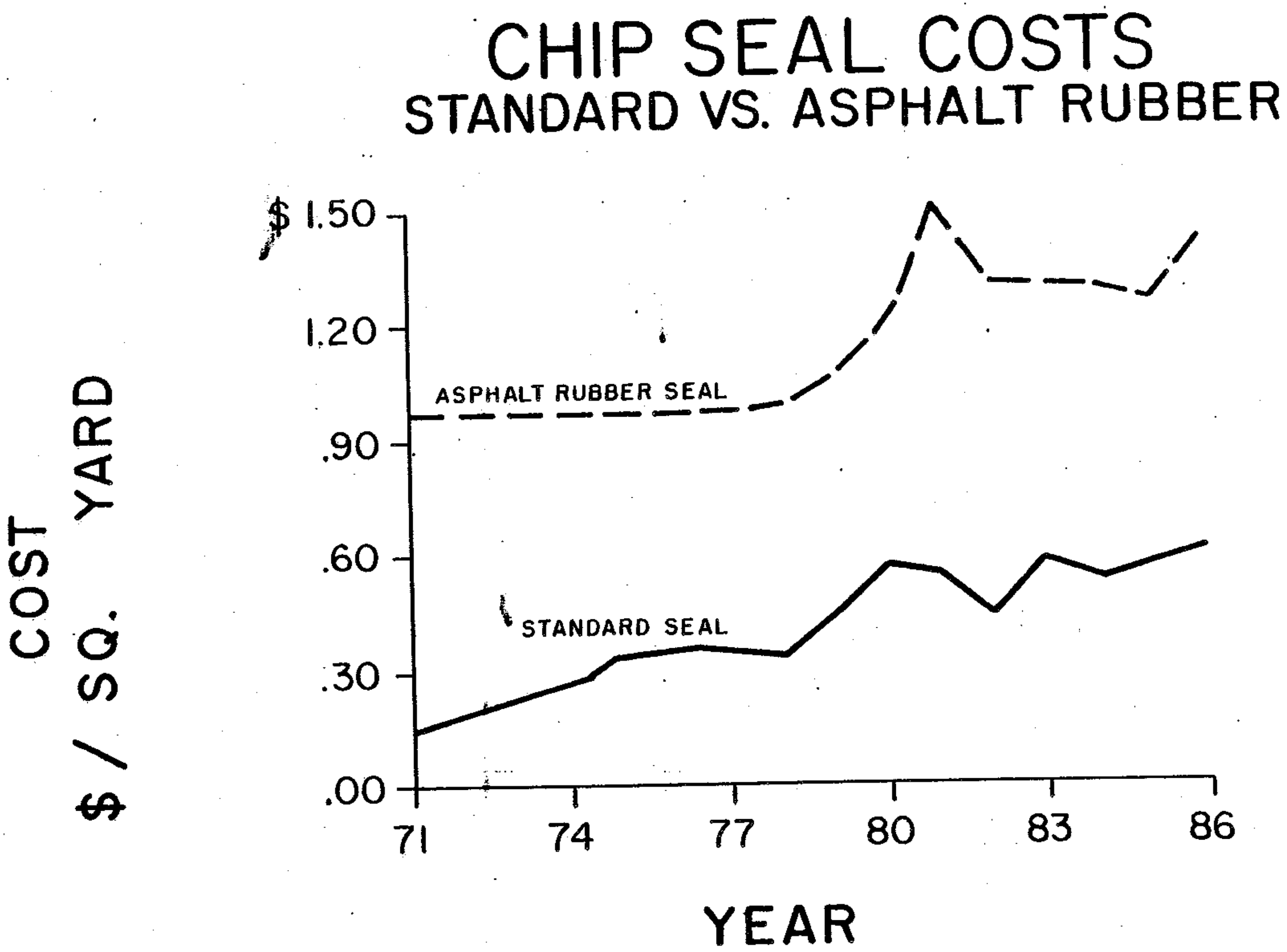

CHIP SEAL COSTS
STANDARD VS. ASPHALT RUBBER
$ 1.50
1.20
.90
.60
.30
.00
ASPHALT RUBBER SEAL
STANDARD SEAL
COST
$ / SQ. YARD
71
74
77
80
83
86
YEAR

FIG. 2

ACTUAL PAVEMENT COST
STANDARD VS. ASPHALT RUBBER SEAL

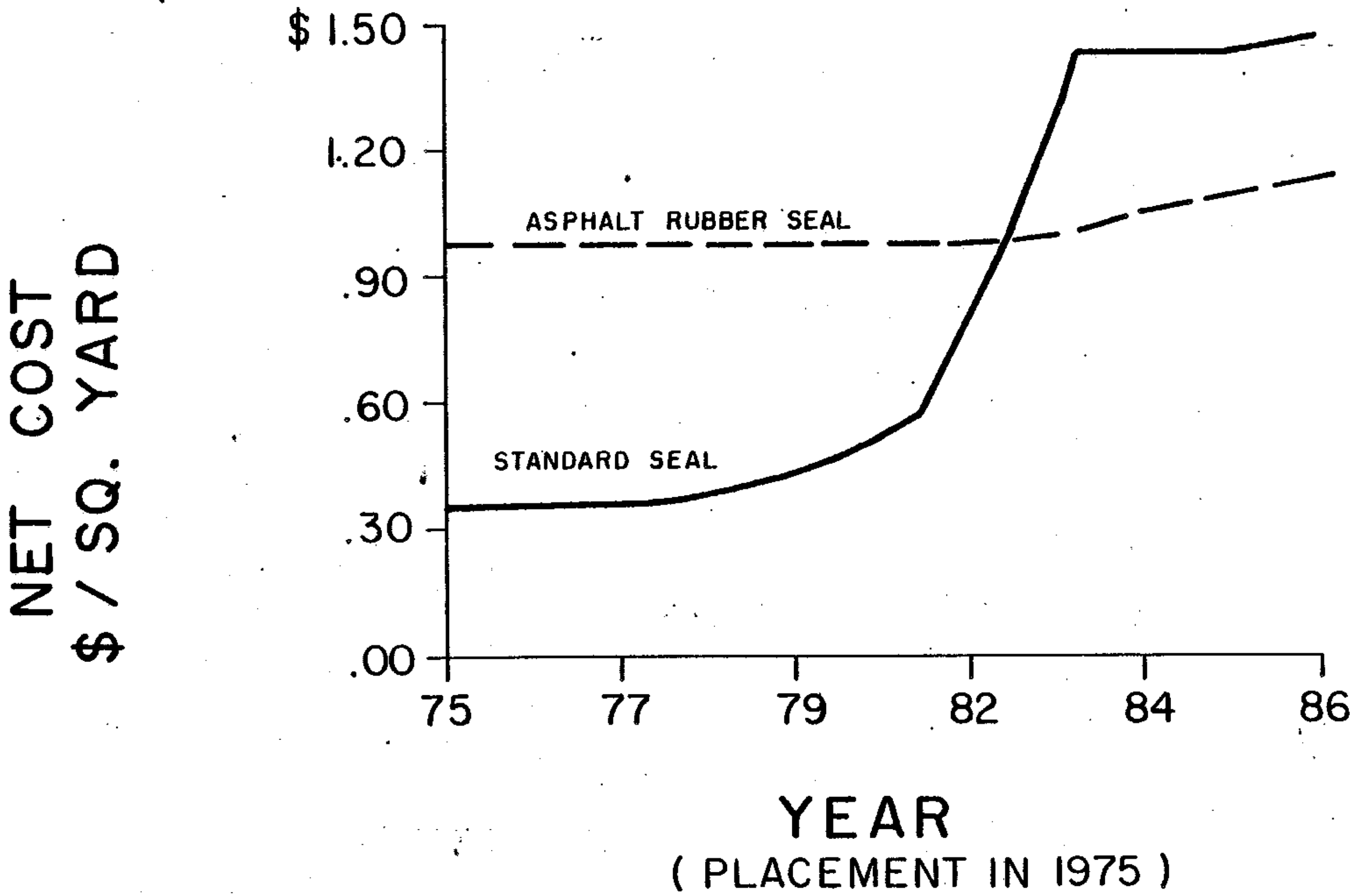


FIG. 3

ASPHALT-RUBBER

RUBBER FILLED ASPHALT CONCRETE

"PlusRide"

Dr. Raymond Pavlovich

Heritage Group West
PO Box 3428
Albuquerque, New Mexico 87190

(Transcribed and edited from the presentation)

Presented at Scrap Tire Recycling and Vendor's Workshop

Sponsored by Fayetteville Technical Institute
North Carolina Association of County Commissioners
and Cumberland County Clean Community Committee

Fayetteville, NC
November 13, 1986

We want to continue with use of recycled or reclaimed rubber in the paving industry. Russ Schnormeier spent some time talking asphalt-rubber where the granulated rubber is reacted with the liquid asphalt, and then used as a binder.

We want to look at rubber-filled asphalt concrete. I would like to speak to you a little bit about asphalt concrete which is the hot mixes that we normally think of and how asphalt or rubber-filled asphalt concrete fits into this scheme. It's part of a hot mix design rather than a binder. I want to talk about the mixture design procedures and about placement of the material and about something on "costing methods," a projected market that at least is estimated as a first cut for North Carolina and some suggested courses of action. We want to address this primarily to the engineers and contractors that will be responsible for the design and construction of these systems and show them what we think in the PlusRide area are some things to be watching for. First a conventional asphalt concrete mixture is a designed mixture of graded aggregants. I want to emphasize that these are designs. They're technology systems and all of the designs for asphalt concrete that you use are custom-built jobs. You've got to use nature's aggregates and Mother Nature is fickle which means that every one of these may be a little bit different and take a look at some of the factors that effect how an asphalt concrete pavement is going to perform. First of course is the aggregate. Now we think that the load carrying capability or the structural capability of an asphalt concrete pavement rests primarily in the aggregate or rock fraction. I point this out because we're going to ask you if you use PlusRide to take another look at the aggregate fraction. Second is the asphalt cement itself. It's the glue that holds the pavement together; keeps the water out; it's responsible for durability and the type and quality of the asphalt are critical. In conventional asphalt rubber, there is a chemical reaction that takes place between the rubber and the asphalt. PlusRide or rubber-filled asphalt concrete is not that dependent on the chemical reaction so its not as sensitive to the asphalt composition as some of the other products are. Third is the production of an asphalt concrete. You can make or break a good pavement in the production. If the production capabilities are not good and the quality is not good, the performance of that pavement will suffer; and the same holds true for PlusRide or rubber-filled asphalt concrete. Last is the placement: How do you build it? Again, in this long chain of events in making a pavement perform, placement can ruin the pavement. Again, this holds true for rubber-filled asphalt concrete. Rubber-filled asphalt concrete or PlusRide is essentially a gap grade asphalt concrete. It's the same kind of hot mix that you use in conventional except we do gap grade the aggregates. Take out some of the rocks sizes and replace that material with crumb rubber, and we do this on a volume basis. PlusRide is the patent tradename for the material. Some of the advantages of using PlusRide as we see it are that it provides some flexing, materials are more elastic, they have more rebound, more give to them. Second, it does improve fatigue resistance. It has a lower modulous. Materials with lower modulous have a higher S-N ratio. It has a greater ultimate strain at failure. You can stretch it farther before it breaks. Finally, it adds a toughness to the mix that you don't see with conventional asphalt concrete. Last and certainly not least by any matter, is the removal of ice. It's been used in northern climates and in Europe for quite a period of time to help remove the thin underlayer of ice that causes skid problems. Now it's not a guarantee but we have noticed that in areas that have been photographed, the areas with PlusRide won't have ice when others do. This is especially true in terms of bridges. What we are trying to say is that PlusRide is the same as conventional asphalt concrete with regards to the keys of production, aggregate control, and placement, except that some of the aggregate has been replaced with rubber. In conventional asphalt concrete large size aggregates have intersteces. These intersteces are filled with smaller aggregates and smaller and smaller on down according to a thing called a Fuller's curve. Some of the aggregates have been replaced with rubber granule particles. These provide the give which gives the elasticity and the toughness. PlusRide presently uses a quarter inch No. 410 and 20 as controlled sieves and normally 3 percent of rubber by weight of mixture is added, sixty pounds to the ton. The part that I think the contractors should be especially interested in are the properties of the PlusRide aggregates. The gap grading, does require some changing in the screens on a hot plant or the screens in the cold screen side. In order to provide this gap in the quarter inch to No. 4 material that PlusRide principally consists of. Setting of these screens and gapping is not that difficult. We've had very good success with it but it is a key to the performance of material. Mixture design procedure for the laboratories that are going to be working with PlusRide goes as follows:

Conventional martial or kneading compaction can be used to produce the specimans that are used for testing. The criteria for a PlusRide or a rubber-filled asphalt concrete are voids and filler debitumen ratio, not stability. The rubber-filled asphalt concrete mixtures are extremely low stability because they give and flex under the load. We're saying right now that it probably is not a structural material so we are thinking of using it in relatively thin lips, inch and a half to two-inch lips in lieu of an open graded friction course or in lieu of part of the surfacing mix. We run a conventional density voids analysis on these mixtures and adjust the mixes to provide the voids ratios that we'll talk about in a minute and we use a specific gravity of rubber of 1.19 to make these volume concentrations and to set the voids content of the mixture. Field procedures when using rubber-filled asphalt concrete are somewhat different than conventional asphalt concrete. PlusRide has been produced in both conventional batch plants as well as drum mixtures. The trick is if a drum mixture is going to be used right now we're recommending a split feed mixture with a recycled suit on it so that the rubber doesn't burn in the mixer. Placement of PlusRide is somewhat different than the conventional material but does not require modifications of the system. The biggest difference is, that you cannot use numatic rollers, the rubber will stick to the numatic rollers so we roll these all a skim and then second, because of the compression and sudden rebound of the rubber particles in the mix, it may need more rolling than a conventional mix, particularly if temparatures are low. Let's look at some cost estimates that we've worked up. I want to separate this concept of cost estimate from pricing. Price is what you pay for it, cost is what it costs you to operate and maintain the material. If one assumes the 145 PCS conventional mix at 5½ percent asphalt content and for a like PlusRide mix, the thing that happens is because of the lower specific gravity of rubber the unit weights of the rubber-filled asphalt concrete are lowered, which means that the same weight gives you about 5 to 7 to 10 percent increased volume. In our cost comparisons, we have included the increased volume of the same weight of material. In general, depending on aggregate and depending on plant flow through cost that I calculate at around a dollar a ton to get the rubber into the plant, if you've got to hand manually open bags and dump it, PlusRide with the royalty will be about 1¼ to 1.9 times the cost of a conventional mix. That's with present costing and pricing. I think that number will go down considerably as the contractors get more used to it, as they get their screen deck set, and as they find better ways to introduce the material that doesn't require such labor and intensive work. Last, we feel that life-cycle cost when one compares not only PlusRide, but any other recycled or recovered resource has to be looked at "life-cycle cost" picture. What we normally do in this area is to take a time span or a cost-analysis period of about 40 years, and we are presently working up a computer program that will say what all the scenarios possible for that stretch of pavement are.

When am I going to overlay it? When am I going to sealcoat it, flushseal it, whatever. Total all of these with your present first cost and with an inflation rate, and then find out what your actual first cost or actual annual cost of the system are. At a 10 percent inflation rate, you're going to find that with two additional years life out of the 8 or 9 year thing, you can afford to pay double down on the front end. These are based on simple discounted cash flow analyses. I think it's something that we have not looked at as deeply and in as much detail as we ought to when one begins to look at first cost or first price. What's the standard way right now of designing a rehabilitation system? I've got this amount of money and hot mix costs me this much a square yard and that's my program. And I think that we have to now start taking a little different look at how the funds are expended. We've made some estimates of a projected market in North Carolina. We've assumed about a half a million tons of asphalt cement utilization. Now I know that varies from time to time. We made a further assumption that 50 percent of the asphalt cement is used in hot mixes. Based on that, we said that there's about five million tons of hot mixes used. That says that you can utilize about 1500 tons of rubber per 1 percent of hot mixes that use 3 percent rubber annually. This is market penetration based on a 1 percent penetration, if you can penetrate 2 percent, use 3,000 tons. That's in rubber-filled asphalt concrete and not in the binders with asphalt rubber. These numbers certainly can be adjusted. As we get better numbers we were speaking with the asphalt institute who couldn't make it here to get a better set of figures on asphalt cement production and hot mix production in the state. I think that the Asphalt Pavement Association of North Carolina can get you these numbers if you want them. Where we get into some other problems is the unintelligent use of these numbers. If you can use it in 1 percent you can't go around assuming that we can penetrate 100 percent of the market because they think the PlusRide people, as well as the asphalt rubber people, will tell you that there are places this can and should be used but there are other places that it shouldn't. Now some suggestions for some courses of action for you, and these are in the form of suggestions, we think that some laboratory studies should be initiated for familiarization with the local materials. What are your local aggregate characteristics and we know they're different in North Carolina than they are in adjacent areas. Hopefully the DOT laboratories can get familiar with these materials and mix designs are a little bit different. You have to get your hands in these materials and get them a little dirty. We would then suggest that you design some modest test sections based on these laboratories studies, and then construct some test sections in highways and city streets heavily traveled, moderate and low travel materials and then monitor the performance of these materials and adjust the design procedures for your own purposes. We know that at North Carolina State University, Dr. Kosler has a good deal of experience with paving materials and performance studies and I think that he would be a good one for some modest efforts at the university level to begin to familiarize with the materials, with the material as a paving material and not particularly looking at it as a method to reuse or recycle wastes. Based on these test sections and performance and I think most of this can be conducted in a year to a year and a half, establish some procedures and specifications as well as performance figures to put into your lifecycle cost studies to find out when and where the materials should be used and how much can't be used. The establishment of No. 4 is going to take some period of time. You cannot accellerate testing of pavement materials. Almost every time we try this, we wind up missing the estimate. So we could take some period to develop these lifecycle costs and then last, there are some specifications available and PlusRide can provide these for you that are ASTM format and are being voted at ASTM now. Let me quickly review what we've talked about. PlusRide or rubberfilled asphalt concrete is the second cousin or the next generation materials along with conventional hot mixed asphalt concrete with the exception that you gap grade the aggregates to provide space for the rubber particles. Mixture design procedure is somewhat different and typical or normal martial or California methods inasmuch as stability is not a criteria. Stability and flow are not. The criteria or voids in filler bitumen ratio. PlusRide field procedures are not too unlike conventional asphalt concrete with the exception that steel wheel rolling should be used rather than conventional numatics so that it won't stick and secondly additional rolling may be required. Our cost estimates on the materials so that it's going to cost you somewhere between one and a quarter to 1.9 times conventional material but they should be based on a lifecycle costing method. Our projected market says 1500 tons percent of the hot mix market that can be penetrated, can be justified to use and lastly there were some courses of action that we think can be started immediately with modest funding that I think are available at the state level or perhaps even the county level to get on with the production and use of this material.

ASPHALT - RUBBER

Rubber Filled Asphalt Concrete

"PlusRide"

TOPICS

1. Asphalt Concrete.
2. Rubber Filled Asphalt Concrete.
3. PlusRide Mixture Properties.
4. PlusRide Mixture Design.
5. PlusRide Field Procedures.
6. Cost Estimates.
7. Projected Market.
8. Suggested Course(s) of Action.

ASPHALT CONCRETE

1. Designed Mixture of Graded Aggregates, Asphalt, and Modifiers.

2. Factors :

   A. Aggregate --- Carries Loads.
      Type and Quantity Critical.

   B. Asphalt --- Cement, Durability.
      Type and Quantity Critical.

   C. Production.

   D. Placement.

RUBBER FILLED ASPHALT CONCRETE

1. Gap Graded Asphalt Concrete Filled With Elastomeris Aggregates (Crumb Rubber).

2. "PlusRide" (Patented).

3. Rubber Imparts Elasticity or "Give".

   A. Claims :

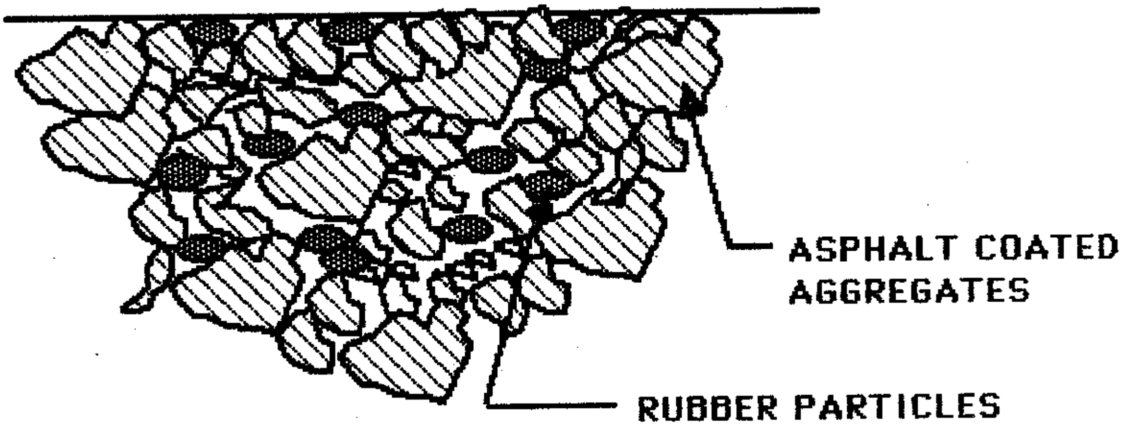
      "Flexing" Provides :

      Improved Fatigue Resistance.

      Greater Ultimate Strain at Failure for Improved Reflection Crack Control.

      "Toughness".

      Ice Removal Aid.



RUBBER FILLED
ASPHALT CONCRETE

Dsk RDP 68 (86-1326)

PLUSRIDE MIXTURE PROPERTIES

3 Percent Rubber by Weight of Mixture (60 Lb. Bag of Rubber Per Ton of Mix).

Rubber Gradation :

Sieve	% Pass
1/4"	100
No. 4	76-100
No. 10	28-42
No. 20	16-24

Aggregate Gradations (Without Rubber):

Sieve	PR-8	PR-12	PR-16
3/4"	100	100	100
5/8"	100	100	-
3/8"	100	60-80	50-62
1/4"	60-80	30-44	30-44
No. 10	23-38	20-32	20-32
No. 30	15-27	13-25	12-23
No. 200	8-12	8-12	7-11

PR 12 And 16 : Pass 1/4, Ret. No. 10 - - 12% Max.
or Pass No. 4, Ret. No. 10 - 10% Max.

Voids Filled With Rubber and Filler. Adjust to 2-4% Voids With F/B +/- 1.0-1.2.

Normally, 7-8% A.C., 1-1% Filler.

PLUSRIDE MIXTURE DESIGN

1. Marshall and Kneading Compaction Procedures Modified to Accomodate Rubber.

2. Voids and Filler/Bitumen Ratio (Not Stability) are Criteria.

3. Conventional Density-Voids Analysis With Rubber Specific Gravity = 1.19.

PLUSRIDE FIELD PROCEDURES

1. **Production.**

   PlusRide Has Been Produced in Conventional Batch and Drum Mixers.

2. **Placement.**

   Cannot Use Rubber Tired Rollers Because Rubber Sticks.

   Additional Rolling May be Necessary to Compensate for Rubber Compression and Rebound.

COST ESTIMATES

1. Assume Conventional Mix at 145 pcf, 5.5% A.C.

   PlusRide at 135 pcf (Approx. 5% Volume Increase), 7% A.C.

2. PlusRide With Royalty Will Be 1.25 to 1.9 Times The Cost of Conventional Mixtures.

3. Life Cycle Costs Should be Considered for the Local Situation.

PROJECTED MARKET(S)

1. Assume Annual Asphalt Cement Utilization at 550,000 Tons (North Carolina).

2. Assume 50% of Asphalt Used in Hot Mixes With Approximately 5,000,000 Tons of Hot Mix Produced.

3. Approximately 1500 Tons of Rubber can be Used If 1% of Hot Mixes Use 3% Rubber.

   (1500 Tons Rubber Per 1% of Hot Mix Market Penetration).

Dsk RDP 68 (86-1326)

SOME SUGGESTIONS

1. **Initiate Laboratory Studies for Familiarization With Local Materials (Aggregates and Rubber).**

2. **Design Test Sections Based on Laboratory Studies.**

3. **Construct Modest Test Sections (Highways and City Streets).**

4. **Establish Procedures (Specifications) and Life Cycle Costs.**

FINAL REPORT

THE EVALUATION OF RUBBER ASPHALT SURFACE TREATMENT IN PREVENTING FATIGUE CRACK REFLECTION IN BITUMINOUS OVERLAY CONSTRUCTION

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North Carolina Department of Transportation

Prepared in Cooperation With
U. S. Department of Transportation
Federal Highway Administration

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ACKNOWLEDGEMENTS

Appreciation is extended to a number of Department staff who encouraged the participation in the Federal Highway Administration Demonstration Project 37, "Discarded Tires In Highway Construction." These include Fourteenth Division Engineer R. W. Spangler, Assistant Division Engineer D. J. Bowers Division Asphalt Superintendent V. A. Thomas, former Resident Engineer R. W. Crisp, Manager of Maintenance & Equipment M. C. Adams, and Design Services Special Projects Engineer L. F. Pace.

INTRODUCTION

This project has been envisioned as a field trial of the use of a rubber asphalt surface treatment. This treatment functions as a stress relief interlayer to delay or prevent the reflection of fatigue cracks into a bituminous concrete overlay. In conducting this field trial, the North Carolina Department of Transportation elected to participate in the Federal Highway Administration Demonstration Project 37, "Discarded Tires In Highway Construction." A highway project was selected in the western region of North Carolina which had experienced rather severe fatigue distress in the original bituminous concrete pavement. It was believed that the inclusion of the rubber asphalt surface treatment with a heavy bituminous resurfacing would enhance the ability of the overlay to withstand fatigue crack reflection.

PROJECT DESCRIPTION

The highway project selected for this field evaluation was the eastbound portion of Interstate Highway 40 in Haywood County from Fines Creek to U. S. Highway 276 (see Figure 1). The total highway section consisted of two 24 foot pavements with 10 foot outside shoulders and a 6 foot median with New Jersey type barrier. The original pavement construction was completed in 1968 and consisted of 14 inches of aggregate base course, 3 inches of bituminous concrete binder, and 2 inches of Type I-2 bituminous concrete surface course. The alignment of this project is depicted in Figure 2. The project began at Station 840 at the Fines Creek interchange and terminated at Station 1140 at the US 276 interchange. In the spring of 1979, a thin bituminous concrete surface course was placed on the eastbound lanes from Station 860 to Station 896 to correct surface problems and failures resulting from a rockslide. Severe fatigue distress had also been observed mainly in the outside travel lane of this highway section during the 1978-1979 period.

Traffic count data have indicated that the 1969 AADT for this section of I-40 was 3,050 vehicles per day, the 1978 AADT was 10,700 vehicles per day, and the 1982 AADT was 13,100 vehicles per day. Projected 2000 year design average annual daily traffic has been revised to approximately 24,000 vehicles per day. It is estimated that heavy truck percentages for this section of roadway will average approximately eighteen percent tractor truck-semi-trailers and approximately four percent single unit, dual tired vehicles. The projected 2000 design year 18 kip single axle loadings per lane has been estimated as approximately 832 applications per day.

This segment of Interstate Highway 40 makes a north-south swing through a portion of the upper Appalachian Highlands. Pavement surface elevations range from 2588 feet at Station 1100 to 2293 feet at Station 870. The higher elevations to the immediate west of this project rise to approximately 5,000 feet above sea level. The major geological substrate includes

Graywacke sandstone and Graywacke conglomerate in thickly graded beds with intervening beds of slate.

The principal native soils along the project included the Ramsey stony loam series and the Halewood stony loam series. Porter's and Ramsey stony rock materials were also indigenous to some locations. The mix of soil materials that were used on the project resulted in clay loam and sandy loam surface characteristics with an A-4 AASHTO classification. Plasticity indices varied from 0 to 9 and liquid limits ranged from 25 to 40 percent. These soil materials graded with retention on the number 10 sieve ranging from 5 to 15 percent and retention on the number 200 sieve ranging from 30 to 50 percent.

The northern portion of Haywood County is considered to be situated in the Temperate Continental Climate Zone, a climate more typical of the North Atlantic and East Central States. Tables 1 and 2 provide fourteen years of climatological data from available local sources which confirm this general climatic classification. Annual rainfall is quite moderate varying from approximately 35 to 60 inches. Annual humidity has been consistently in the range of 70% to 80%. Annual temperature extremes have been quite significant. 1974 recorded the least annual extreme of approximately seventy-six degrees Fahrenheit whereas 1970 and 1980 registered temperature extremes of one hundred degrees Fahrenheit or more. The average temperature extreme for the fourteen year period has been approximately ninety-two Fahrenheit degrees.

The average annual frost penetration depth for the project vicinity is approximately 10 inches. Maximum frost penetration depth is estimated to be approximately 15 inches for this mountainous region. Table 2 indicates that the average number of annual freeze thaw cycles for this region is approximately 86 cycles. On the average, eight of these cycles have lasted for two days or longer. The maximum extended freeze cycle since 1969 has been observed to be approximately 8 days. The freeze susceptibility period will extend from early October to mid May.

CONSTRUCTION EXPERIENCE

Work began on August 14, 1979 to rehabilitate the eastbound lane pavement surface with a heavy asphalt resurfacing. The basic resurfacing consisted of approximately one and one-half inches of type H bituminous concrete binder course and approximately one inch of type I-2 bituminous concrete surface course. Included in the resurfacing was a rubber asphalt surface treatment which was placed directly upon the original surface material as follows:

- From Station 842 to Station 882 - Outside Lane Treatment Only
- From Station 882 to Station 920 - Treatment to Both Lanes
- From Station 920 to Station 949 - Outside Lane Treatment Only
- From Station 949 to Station 959 - No Treatment (Control Section)
- From Station 959 to Station 1028 - Treatment to Both Lanes
- From Station 1028 to Station 1054 - Outside Lane Treatment Only
- From Station 1054 to Station 1060 - Treatment to Both Lanes
- From Station 1060 to Station 1071 - Outside Lane Treatment Only
- From Station 1071 to Station 1077 - No Treatment
- From Station 1077 to Station 1121 - Outside Lane Treatment Only
- From Station 1121 to Station 1140 - No Treatment (Control Section)

The placement of the rubber asphalt surface treatment was concluded on August 21, 1979. In each sequence of daily activity for the placement of this special treatment, the rubber asphalt was immediately covered with the type H binder. Table 3 contains a record of pertinent construction data relative to the rubber asphalt treatment application. Pertinent construction features are documented in Photographs 1 through 9 in the Appendix. The specifications for the construction materials and equipment are also contained in the Appendix.

Photograph 1 depicts the 100% vulcanized rubber utilized in the rubber asphalt mixture. This material was supplied by Sahuaro Petroleum Company in 60 pound sacks. It was recommended by this supplier that 100% vulcanized rubber be used in lieu of a vulcanized-devulcanized blend to preclude the use of higher mixing temperatures. This would save energy and provide a more homogeneous mixture.

The complement of heavy equipment used on this project consisted of 1 rubber asphalt distributor, 1 chip spreader, 2 pneumatic rollers, and 6 tandem dump trucks.

Photograph 2 depicts the 4,500 gallon rubber asphalt distributor utilized by the contractor. This unit was equipped with a Number 5 spraybar for mixture application. The tank on the distributor was equipped with baffles and augers to provide continuous mixing. This photograph also illustrates the direct feed conveyor system that was used to load the crumb rubber into the top of the distributor.

The procedure followed was to fill the tank with a prescribed amount of AC-10 and to heat the asphalt to approximately 375°F. Crumb rubber was then introduced into the tank and the mixture was retained at this temperature for approximately 60 minutes. After this reaction period, kerosene was added at a rate ranging from 3.3% to 4.5% by volume. The reaction period for the kerosene was limited to approximately 3 minutes. The application of this diluent lowered the mix temperature to the range of 330°F to 350°F for application to the pavement. Viscosity of the mixture was constantly monitored throughout the process with the viscosity readings ranging from 11,000 to 12,500 centipoises.

Photograph 3 depicts the equipment train for this construction. It is noted that the movement of the distributor and the chip spreader was counter to that of the traffic being maintained in the adjacent lane. Photograph 4 illustrates the spray application of the mixture. The application rate varied from approximately .55 to .69 gallon per square yard.

The cover aggregate applied to the rubber asphalt mixture complied with the North Carolina #6 specifications. The use of the chip spreader is shown in Photograph 5. The aggregate was placed within 2 to 3 minutes of the letdown of the rubber asphalt mixture. As shown in Photograph 6, pneumatic tired rollers were used to set the cover aggregate into the rubber asphalt mixture. A minimum of four passes was made with the rollers on each pavement section. A closeup view of the rolled in aggregate is depicted in Photograph 7. Although the contract special provisions permitted the use of blotter materials, excess asphalt did not come through the cover aggregate to the point of requiring the use of sand or other blotter material.

As shown in Photograph 8, the back edge of transverse construction joints was covered with 18 inch wide roofing type paper. This facilitated the placement of the rubber-asphalt mixture on the forward edge without creating a double shot effect. Longitudinal construction joints were simply pulled even by adjusting the positioning of the spraybar and the aggregate feeder.

Each rolled in membrane was covered with bituminous concrete binder course on the same day of construction. The curing time for the membrane was limited to a maximum of 90 minutes before application of the tack coat. CRS-1H liquid was applied directly to the membrane at a rate of .08 gallon per square yard. The one and one-half inch binder course was promptly applied to the rubber asphalt surface treatment and traffic was promptly returned to the lane. Photograph 9 depicts the sequence that was used to bring all rubber asphalt surface treatment and bituminous binder treatment up to a common transverse joint at the end of each construction day. This precaution was necessary to avoid safety problems which would have resulted if longitudinal construction joints had been permitted between construction periods.

The placement of the one inch Type I-2 bituminous concrete surface course was accomplished during the period August 23, 1979 to August 31, 1979. Design specifications and job mix formulations for the binder and surface course materials are furnished in Tables 4 and 5.

PERFORMANCE OBSERVATIONS

Continuous observation has been made of the rubber asphalt treated section since the completion of construction. These viewings have revealed that during the first three years of service the rubber asphalt treated sections have withstood the early reflection of fatigue or alligator type cracks. Photographs 10 through 17 in the Appendix provide visual comparison of areas of significant physical distress prior to treatment in 1979 versus the condition of these same areas in January 1983. Other general observations of minor distress including rutting and fatigue cracking which have been noted during the initial three year period are illustrated in Photographs 18 through 25.

The combined usage of intermediate binder course and rubber asphalt surface treatment has precluded the making of any firm, separate judgments about the latter measure. During the 1979 through 1982 service period, the reflective cracking through the overlay was very minimal. Early signs of fatigue crack development were limited to untreated control sections. One instance of random crack reflection, probably due to subgrade instability, was observed in the fully treated sections. Rutting has been infrequent. A limited number of localized depressions have appeared in the pavement surface. Continuous wheel path ruts have been limited to a few locations along the eastern-most mile section with mean depths of no more than one-quarter inch.

It is suspected that the superior condition of the rehabilitated pavement will remain for a limited duration. Within the limits of the pavement rehabilitation, there are three structures along the project, two stream crossings and a forest service road underpass, which required alterations to the basic rehabilitation treatment. The approach and leave pavement sections to these structures required the elimination of the type H binder treatment and the feathering down of the bituminous concrete overlay. These measures were required during construction to eliminate excessive surface dropoff onto the bridge decks. Along these pavement approaches, the rubber asphalt surface treatment was applied to the normal depth up to the limits of the structure curtain walls. In 1981, crack reflections due to subgrade instability and embankment settlement were observed in the bituminous concrete overlay along these approaches. These distresses were observed to increase in 1982 as can be noted in Photographs 24 and 25. It is believed that these pavement failures are signs of the imminent distress which will appear in the rubber asphalt treated sections. It is believed, however, that these distresses will occur to a greater degree in the control sections. Moreover, it is suspected that the fatigue crack reflection will be more prominent in the outside travel lane, consistent with the heavy vehicle distribution and the relative degree of distress in the original pavement surface.

It is important to note that the rehabilitated pavement section has provided excellent service and ride quality during the initial three year, post rehabilitation period. As rutting was observed to be minimal during 1980 and 1982, the gathering of deflection data utilizing the Benklemann Beam was not viewed as essential during that period. Also during that period, roughness measurement from the BPR roughometer ranged in the 60 inches per mile to 70 inches per mile interval. This measure of performance has been considered to be satisfactory. On the basis of test observations from two fully treated pavement sections and one control section, surface skid resistance has remained very good throughout the three year period. This high level of serviceability has been quite significant in view of the heavy traffic and the severe winter environmental conditions which have persisted along this section of Interstate Highway 40.

FINDINGS

1. There was an optimum arrangement for assigning the construction equipment during the placement of the rubber asphalt surface treatment. The ratio of six aggregate supply trucks to one mixture distributor worked extremely well in achieving consistent daily production rates from 3,000 to 5,000 lineal feet. Operation was continuous, mixture processing delays were minimal, and rubber asphalt overspray losses were minimal.

2. Environmental concerns during the construction operation were not manifested to any serious degree. This included such things as excessive smoke from the distributor during the mixture heating process, surface haze from the spraying of the mixture onto the pavement, and dust generation during the aggregate spraying process.
3. The use of a blotter material on the rubber asphalt surface treatment was eliminated inasmuch as the binder course was placed atop this treatment along most rehabilitated sections. This action proved to be prudent. This enhanced the bond between the rubber asphalt surface treatment and the binder course. Any asphalt drift into the binder course was absorbed and did not result in visible surface flushing. Asphalt flushing was not observed to be a problem along the feathered pavement approaches to three structures on the project.
4. Special treatment of the large crevices in the original pavement surfaces probably would have been advantageous to the long term performance of the rehabilitated pavement. The use of a light rubber asphalt crack sealer would have enhanced the bond of the rubber asphalt surface treatment to localized areas of distress. In turn, this application would have enhanced the long term structural performance of the intermediate, binder course material.

5. The three year performance of the total pavement rehabilitation treatment has been very satisfactory. The additional pavement structure provided by the binder course and wearing surface has been serviceable and free of deficiency. The rubber asphalt surface treatment has adequately supported this additional pavement structure and has provided satisfactory relief from stresses which have existed in the underlying bituminous layers. It is believed that these aspects of performance have enabled the rubber asphalt treatment to provide some degree of impermeability to surface moisture intrusion into the original pavement layers. Although this impermeability cannot be considered as having been totally complete, it has prolonged or forestalled the progressive appearance of fatigue distress in the bituminous overlay surface. Unimpeded moisture infiltration into the crevices of the original distressed areas would have readily manifested itself into some surface course failures under the severe winter environmental exposures of this highway project.

6. Visual surveys made in mid 1979 confirmed that approximately 15,500 lineal feet of the eastbound travel lane had succumbed to severe fatigue distress during an eleven year service period. This amounted to approximately fifty-two percent of the travel lane along this section of the roadway. Through 1982, less than one hundred lineal feet of the fully rehabilitated outside travel lane had shown any sign of renewed fatigue distress.

RECOMMENDATIONS

This rubber asphalt treated, fully rehabilitated pavement should provide satisfactory performance for an extended period. The composite pavement surface consists of approximately fourteen inches of aggregate base course and approximately eight inches of asphaltic materials. Surveillance of the structural condition of the asphaltic layers will be essential toward achieving this prolonged service. Benklemann Beam tests, or other suitable measures of structural deflection, beginning in 1983 and rescheduled at approximately two year intervals will be beneficial. Prompt attention to sealing singular cracks that reflect through into the wheel paths of the travel lane will slow the development of major fatigue distress in the overlay materials. This will also help maintain an acceptable riding surface. With this limited additional support, the serviceability of the rubber asphalt treated section should extend into the late 1980's or beyond.

This study has not determined that rubber asphalt surface treatment used alone with bituminous concrete resurfacing will provide long term relief from severe fatigue distress. The results with the binder and surface course rehabilitation strategy have been encouraging. These results have suggested that rubber asphalt surface treatment can be a useful, cost effective inclusion to pavement rehabilitation measures. Other applications of rubber asphalt surface treatment on North Carolina highways should be considered on the basis of specific project needs.

APPENDIX

FIGURES

AND

TABLES

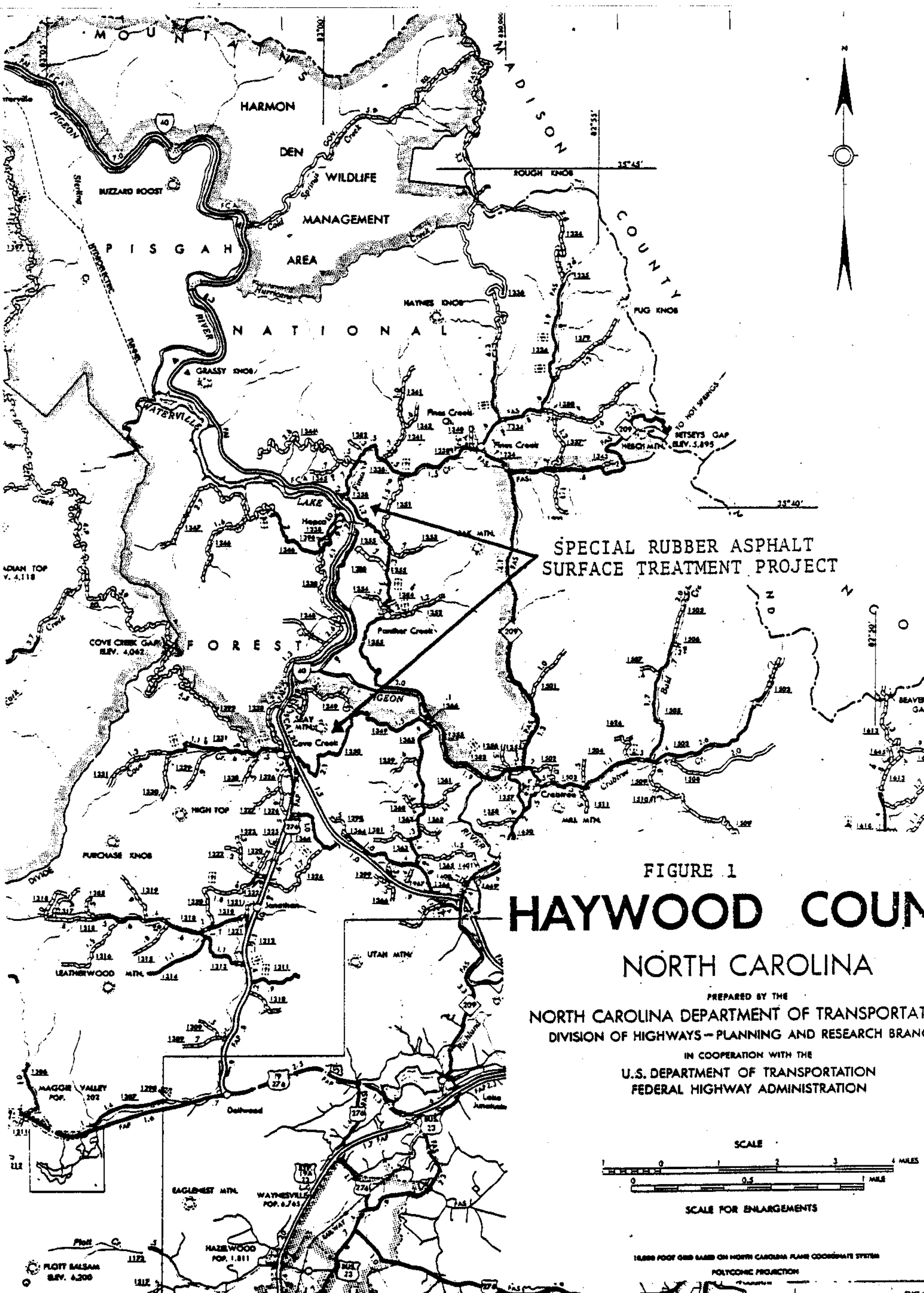
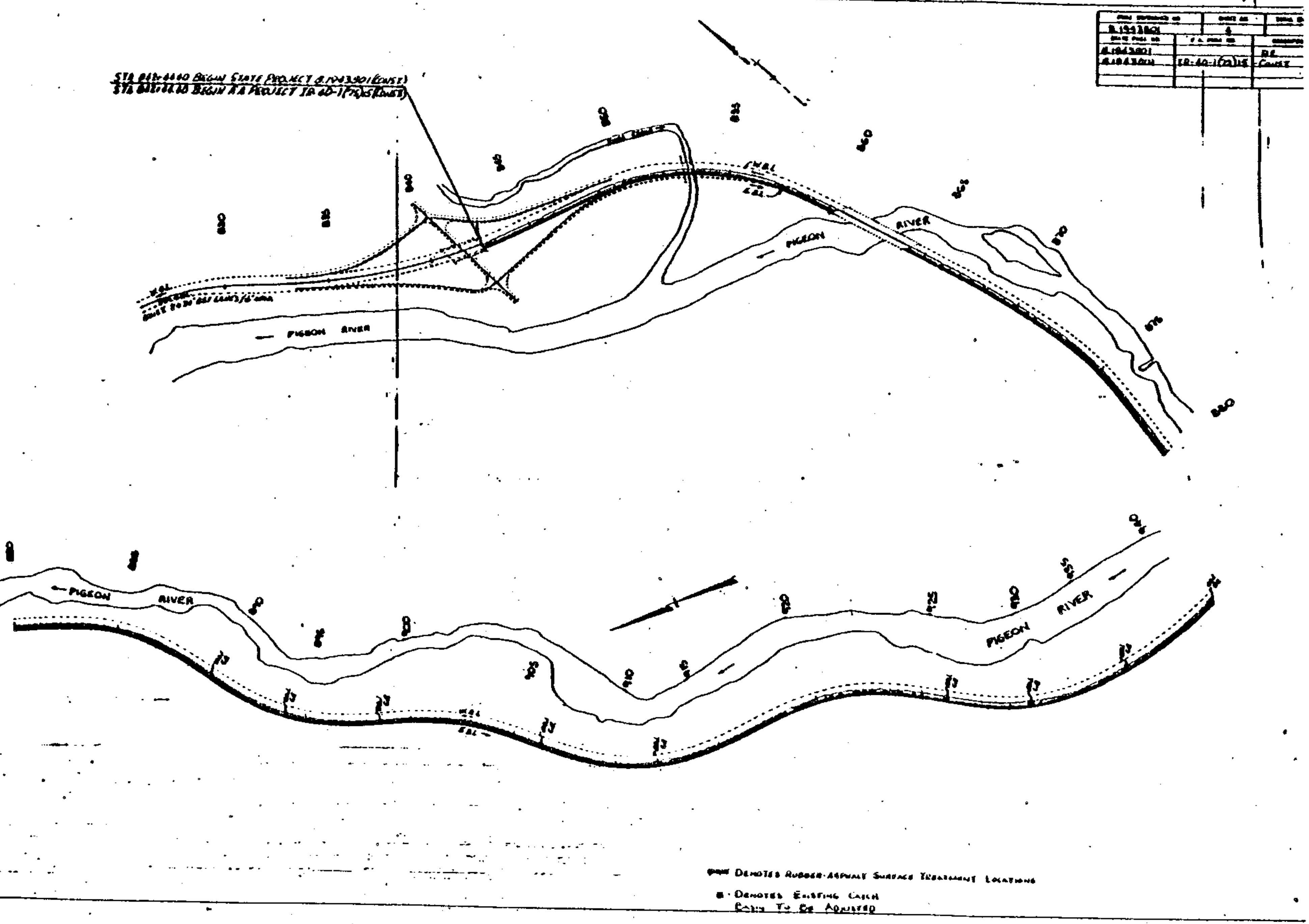

SPECIAL RUBBER ASPHALT
SURFACE TREATMENT PROJECT
HAYWOOD COUN
NORTH CAROLINA
PREPARED BY THE
NORTH CAROLINA DEPARTMENT OF TRANSPORTAT
DIVISION OF HIGHWAYS — PLANNING AND RESEARCH BRAN
IN COOPERATION WITH THE
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
SCALE
SCALE FOR ENLARGEMENTS
POLYCONIC PROJECTION
MOUNTAINS
HARMON
DEN
WILDLIFE
MANAGEMENT
AREA
PISGAH
NATIONAL
FOREST
MADISON
COUNTY
ROUGH KNOB
HAYNES KNOB
PUG KNOB
GRASSY KNOB
BUZZARD ROOST
WATERVILLE
PIGEON
RIVER
LAKE
Pines Creek
BETSEYS GAP
ELEV. 5,895
TO HOT SPRINGS
OAK MTN.
Panther Creek
COVE CREEK GAP
ELEV. 4,062
Cove Creek
HIGH TOP
PURCHASE KNOB
DIVIDE
Crabtree
MILL MTN.
UTAH MTN.
LEATHERWOOD MTN.
MAGGIE VALLEY
POP. 202
Dellwood
Lake Junaluska
EAGLENEST MTN.
WAYNESVILLE
POP. 6,765
HAZELWOOD
POP. 1,811
PLOTT BALSAM
ELEV. 6,200
Plott Cr.
Jonathan

FIGURE 1



STA 843+44.40 BEGIN STATE PROJECT 8.1943901 (CONST)
STA 843+44.40 BEGIN F.A. PROJECT IR-40-1(72)15 (CONST)
PIGEON RIVER
PIGEON
RIVER
PIGEON RIVER
PIGEON RIVER
Denotes Rubber-Asphalt Surface Treatment Locations
Denotes Existing Catch Basin To Be Adjusted

FIGURE 2

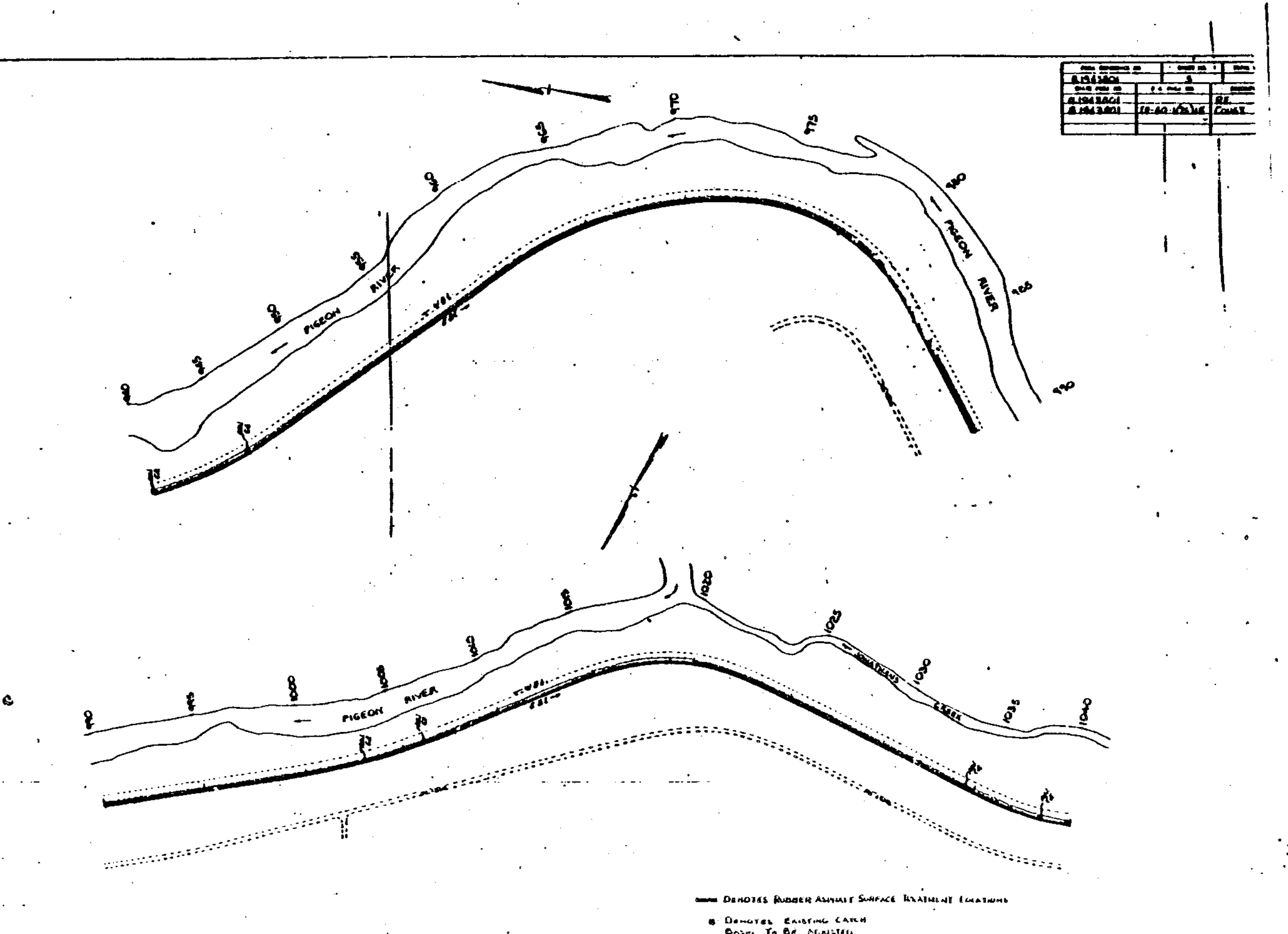
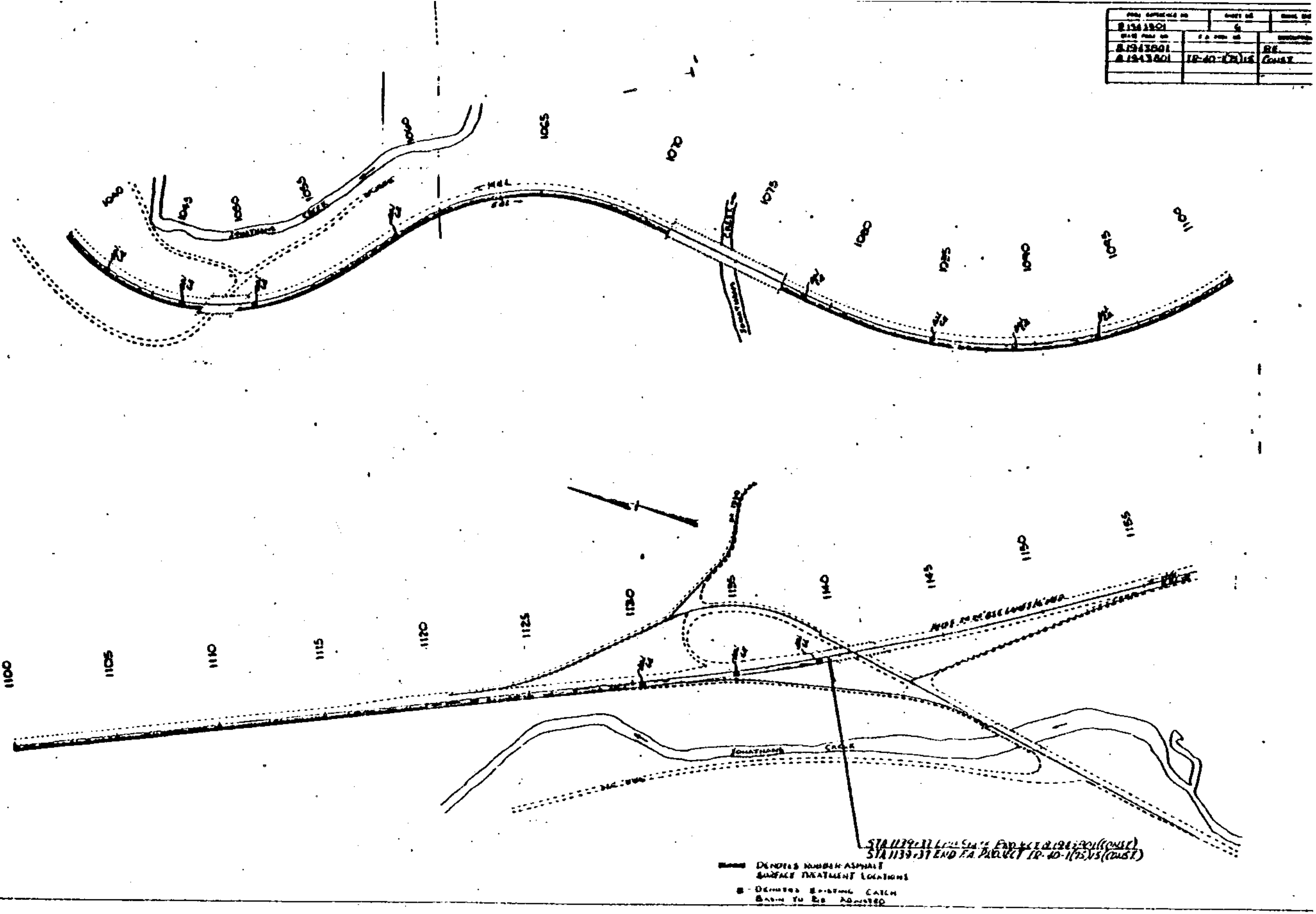

PIGEON RIVER
975
980
985
990
PIGEON RIVER
PIGEON RIVER
1020
1025
1030
1035
1040
JONATHANS CREEK
DENOTES RUBBER ASPHALT SURFACE TREATMENT LOCATIONS
DENOTES EXISTING CATCH BASIN TO BE ADJUSTED

FIGURE 2



1040
1045
1050
1055
1060
1065
1070
1075
1080
1085
1090
1095
1100
1105
1110
1115
1120
1125
1130
1135
1140
1145
1150
1155
8.1943801
IR-40-1(75)15
DENOTES RUBBER-ASPHALT SURFACE TREATMENT LOCATIONS
DENOTES EXISTING CATCH BASIN TO BE ADJUSTED

FIGURE 2

TABLE 1

LOCAL CLIMATOLOGICAL DATA

Year	Average Annual Rainfall (Inches)	Average Annual Humidity (%)	Highest Recorded Temperature (°F)	Lowest Recorded Temperature (°F)
1969	43.54	76	89°	1°
1970	35.77	78	89°	-16°
1971	48.26	77	87°	-4°
1972	52.87	79	88°	-7°
1973	51.13	77	86°	2°
1974	48.70	76	85°	9°
1975	57.02	79	89°	2°
1976	52.11	74	88°	-5°
1977	50.45	71	89°	-5°
1978	39.26	75	89°	-2°
1979	57.96	79	89°	-2°
1980	43.76	76	94°	-6°
1981	39.52	75	90°	-4°
1982	46.76	N.A.	88°	-11°

Source of Rainfall and Temperature Data: Western Mountain Agricultural Research Station, Waynesville, North Carolina, Latitude 35°-29' North, Longitude 82°-57' West, Elevation - 2658 Feet.

Source of Humidity Data: National Weather Service Station, Asheville, North Carolina, Airport, Latitude 35°-26' North, Longitude 82°-32' West, Elevation - 2140 Feet.

TABLE 2

FREEZE-THAW CONDITIONS

PIGEON RIVER GORGE VICINITY-HAYWOOD COUNTY

Period	Approximate Number of Freeze-Thaw Cycles	Approximate Number of Diurnal Cycles	Approximate Number of Extended Cycles	Maximum Extended Cycle	Earliest Freeze	Latest Freeze
October 1, 1969 to May 31, 1970	92	83	9	5 days	October 18, 1969	May 7, 1970
October 1, 1970 to May 31, 1971	90	78	12	4 days	October 4, 1970	May 4, 1971
October 1, 1971 to May 31, 1972	92	87	5	4 days	October 8, 1971	April 28, 1972
October 1, 1972 to May 31, 1973	80	75	5	7 days	October 1, 1972	May 18, 1973
October 1, 1973 to May 31, 1974	72	68	4	2 days	October 17, 1973	April 25, 1974
October 1, 1974 to May 31, 1975	87	82	5	3 days	October 1, 1974	April 22, 1975
October 1, 1975 to May 31, 1976	90	81	9	3 days	October 3, 1975	May 19, 1976
October 1, 1976 to May 31, 1977	96	86	10	8 days	October 15, 1976	May 11, 1977
October 1, 1977 to May 31, 1978	88	75	13	7 days	October 4, 1977	May 3, 1978
October 1, 1978 to May 31, 1979	92	83	9	4 days	October 9, 1978	April 30, 1979
October 1, 1979 to May 31, 1980	72	65	7	5 days	October 6, 1979	May 10, 1980
October 1, 1980 to May 31, 1981	95	88	7	4 days	October 6, 1980	May 9, 1981
October 1, 1981 to May 31, 1982	73	67	6	4 days	October 3, 1981	April 24, 1982
AVERAGE:	86	78	8			

Source of Data: Daily Temperatures Compiled At Western Mountain Agricultural Research Station, Waynesville, North Carolina, Latitude 35°-29' North, Longitude 82°-57' West, Elevation - 2658 Feet.

TABLE 3

RUBBER ASPHALT TREATMENT FIELD CONSTRUCTION DATA

Work Date	Work Limits	Shot Length (Lineal Feet)	Rubber Asphalt Application Rate (Gallons/Square Yard)	Rubber To Asphalt Ratio (By Weight)	Diluent Rate By Volume (Per Cent)	Application Temperature (°F)	Daily Ambient Air Temperature Range (°F)
8/14/79	Station 842 to Station 862 & Station 864 to Station 882 (Outside Lane)	4,000	.600	.362	4.4	340	60 - 92
8/15/79	Station 882 to Station 920 (Inside Lane)	3,800	.669	.360	4.4	330	56 - 79
	Station 882 to Station 899 (Outside Lane)	1,700	.551	.383	4.3	340	56 - 79
8/16/79	Station 899 to Station 949 (Outside Lane)	5,000	.594	.357	4.4	340	56 - 80
8/17/79	Station 959 to Station 990 (Outside Lane)	3,100	.624	.360	4.4	330	55 - 85

TABLE 3

RUBBER ASPHALT TREATMENT FIELD CONSTRUCTION DATA

Work Date	Work Limits	Shot Length (Lineal Feet)	Rubber Asphalt Application Rate (Gallons/Square Yard)	Rubber To Asphalt Ratio (By Weight)	Diluent Rate By Volume (Per Cent)	Application Temperature (°F)	Daily Ambient Air Temperature Range (°F)
8/17/79	Station 959 to Station 990 (Inside Lane)	3,100	.607	.363	4.4	350	55 - 85
8/18/79	Station 990 to Station 1028 (Inside Lane)	3,800	.657	.361	4.5	350	59 - 90
	Station 990 to Station 1029 (Outside Lane)	3,900	.639	.375	3.3	350	59 - 90
8/20/79	Station 1029 to Station 1071+50 (Outside Lane)	4,250	.617	.360	4.4	330	62 - 90
	Station 1054 to Station 1060 (Inside Lane)	600	.625	.360	4.4	335	62 - 90
8/21/79	Station 1077+65 To Station 1121 (Outside Lane)	4,335	.685	.360	4.4	335	60 - 92

TABLE 4

NORTH CAROLINA DESIGN SPECIFICATIONS

TYPE H BITUMINOUS CONCRETE BINDER COURSE

Sieve Designation	Total Per Cent Passing	Job Mix Tole
1"	100%	0%
3/4"	90% - 100%	±5%
1/2"	67% - 88%	±8%
No. 8	25% - 45%	±5%
No. 200	1% - 7%	±2%
Asphalt Content	3.5% - 6.5% Range	±0.5% r toleran
Temperature	250° - 300°F Range	± 15°F toleran
Marshall Stability	1,000 Pounds Minimum	
Marshall Flow Reading	7 - 14	
Marshall Void Content	3% - 9%	

TABLE 5

NORTH CAROLINA DESIGN SPECIFICATIONS

TYPE I-2 BITUMINOUS CONCRETE SURFACE COURSE

Sieve Designation	Total Per Cent Passing	Job Mix Tolerance
3/4"	100%	0%
1/2"	96% - 100%	±2%
3/8"	90% - 100%	±5%
No. 4	70% - 95%	±7%
No. 8	55% - 75%	±5%
No. 40	15% - 45%	±5%
No. 80	7% - 22%	±5%
No. 200	3% - 9%	±2%
Asphalt Content	4.5% - 8.5%	±0.5% Mix Tolerance
Temperature	250°F - 300°F Range	±15°F Mix Tolerance
Marshall Stability	600 Pounds Minimum	
Marshall Flow Reading	7 - 14	
Marshall Void Content	4% - 10%	

<u>CONSTRUCTION</u>

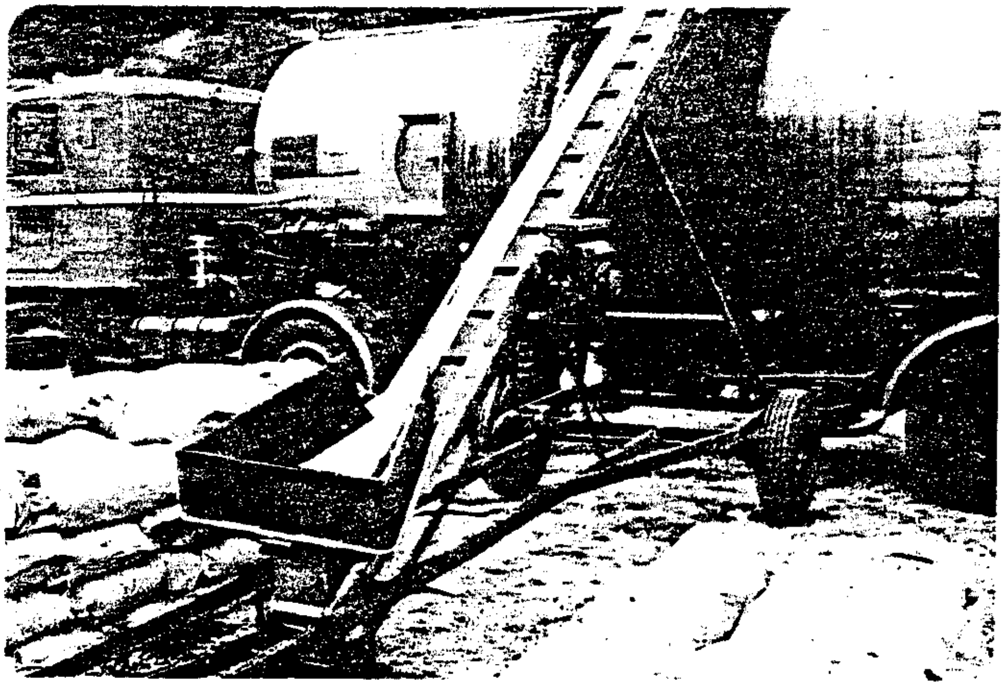
<u>SEQUENCE</u>

<u>PHOTOGRAPHS</u>

PHOTOGRAPH 1

Vulcanized Rubber
In 60 Pound Sacks

August 1979



PHOTOGRAPH 2

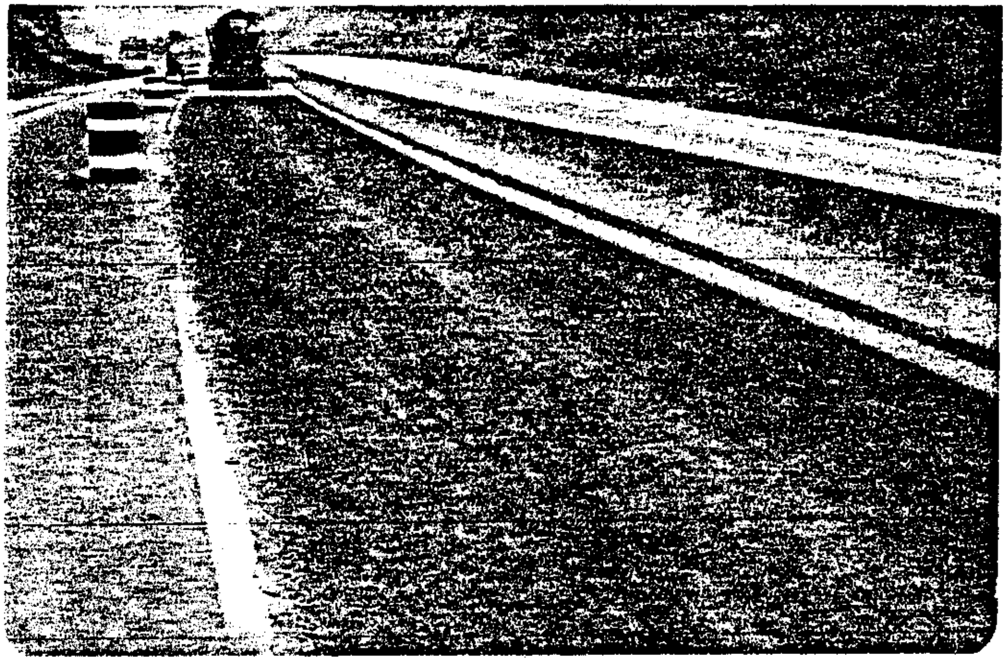
Rubber Asphalt
Distributor And
Loading Conveyor

August 1979

PHOTOGRAPH 3

Equipment Train

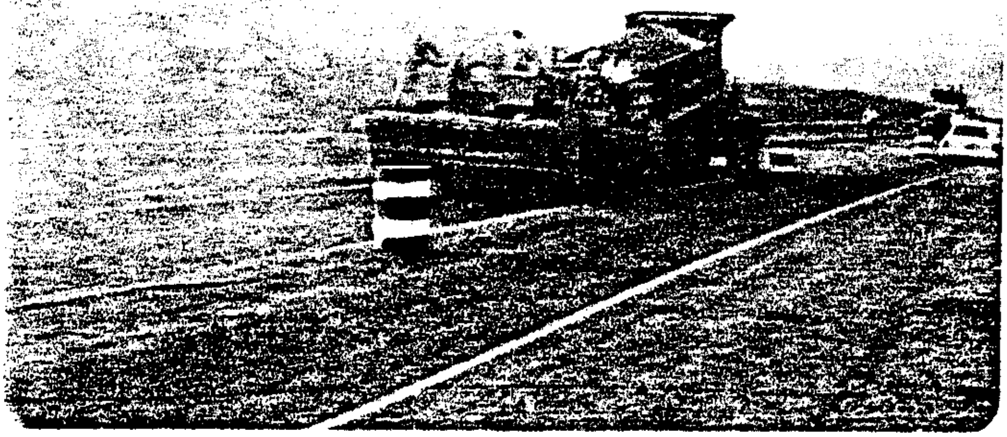
August 1979



PHOTOGRAPH 4

Rubber Asphalt
Spray Applicat

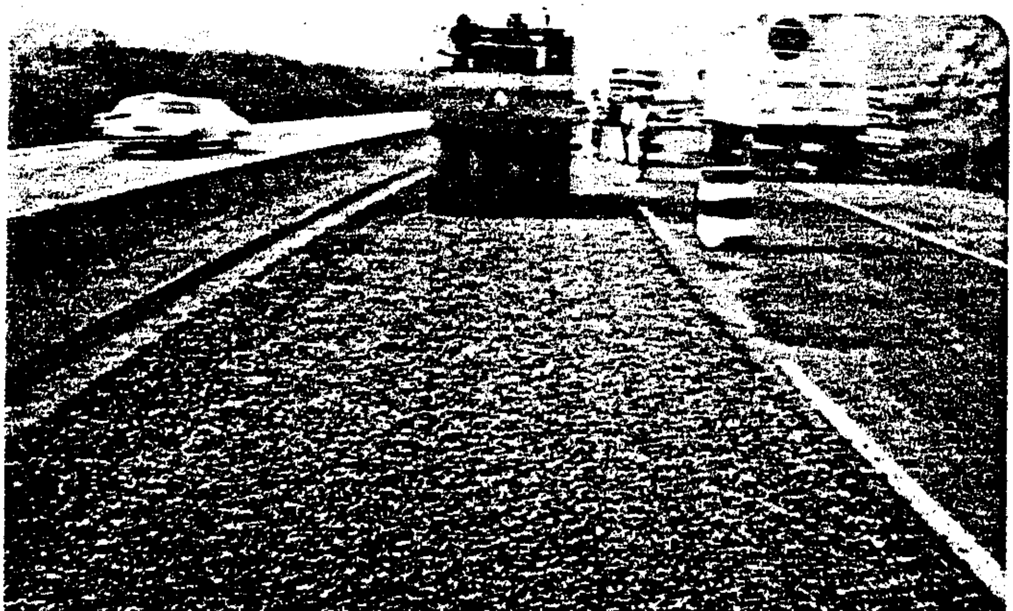
August 1979



PHOTOGRAPH 5

Chip Spreader

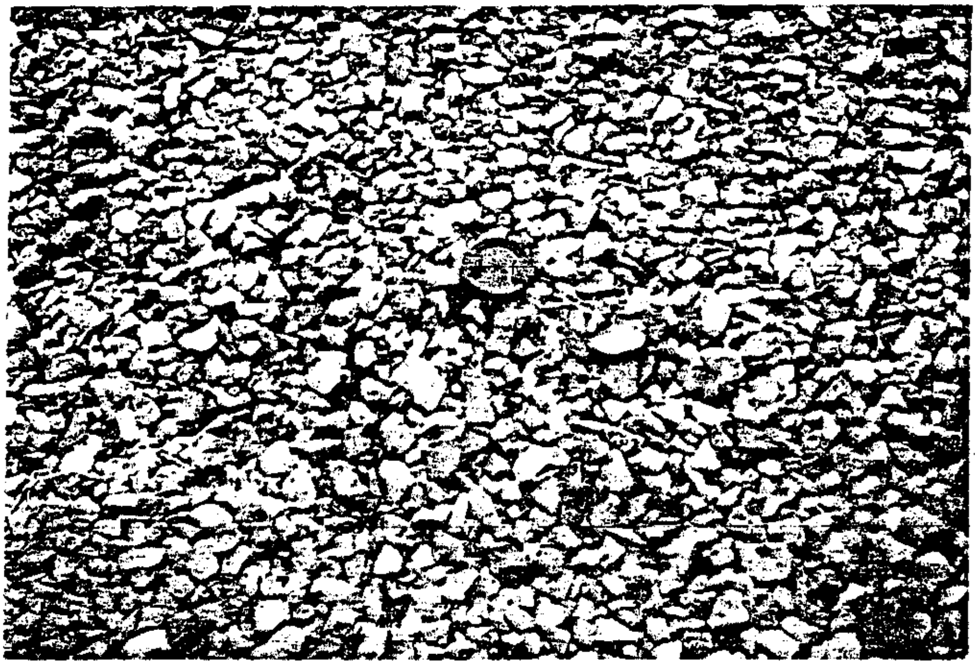
August 1979



PHOTOGRAPH 6

Compaction of
Aggregate With
Pneumatic Tired
Roller

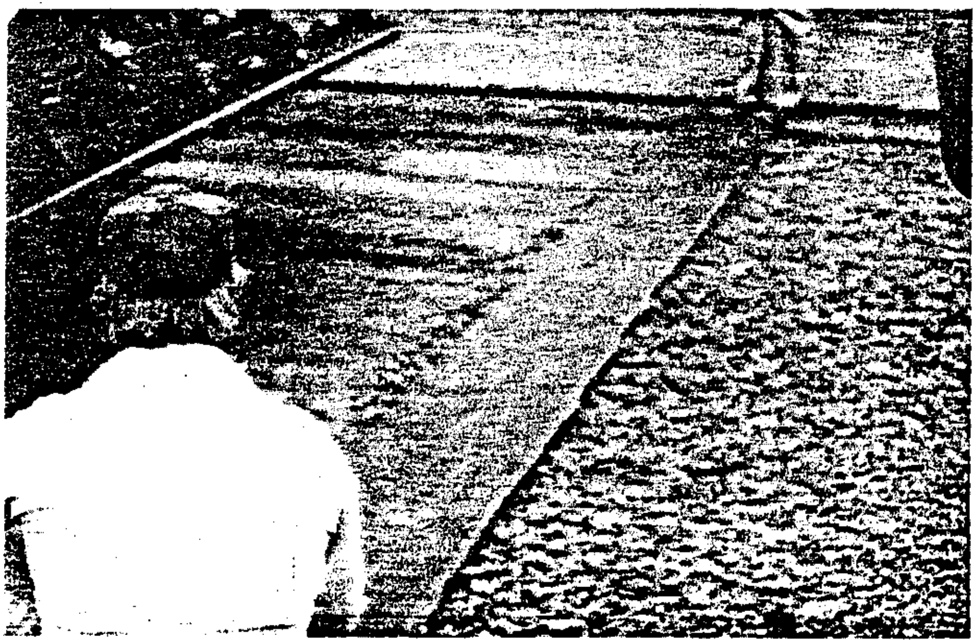
August 1979



PHOTOGRAPH 7

North Carolina
Number 6 Aggregate
Mix

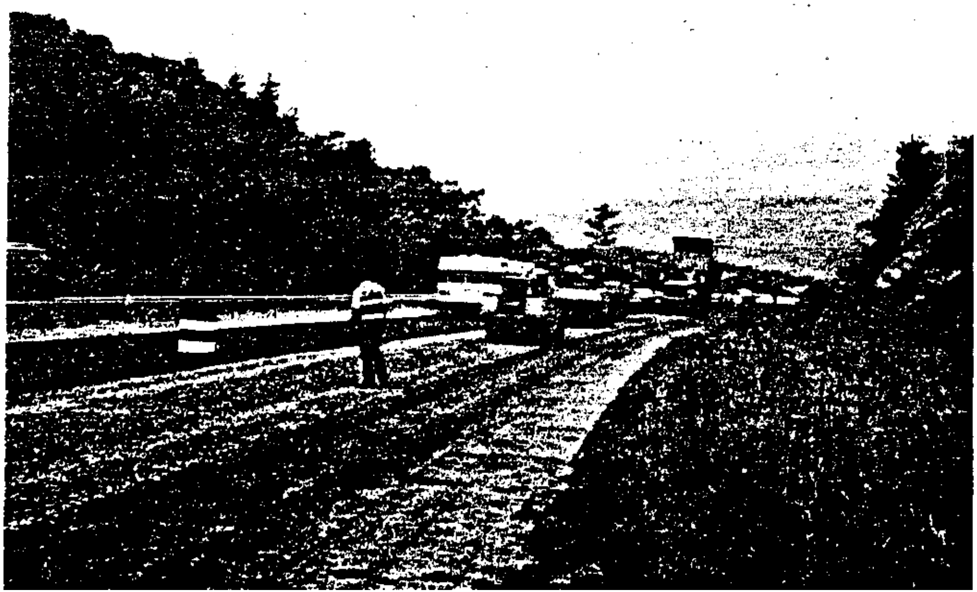
August 1979



PHOTOGRAPH 8

Transverse Joint
Construction
Treatment

August 1979



PHOTOGRAPH 9

Typical Daily
Construction
Sequence

August 1979

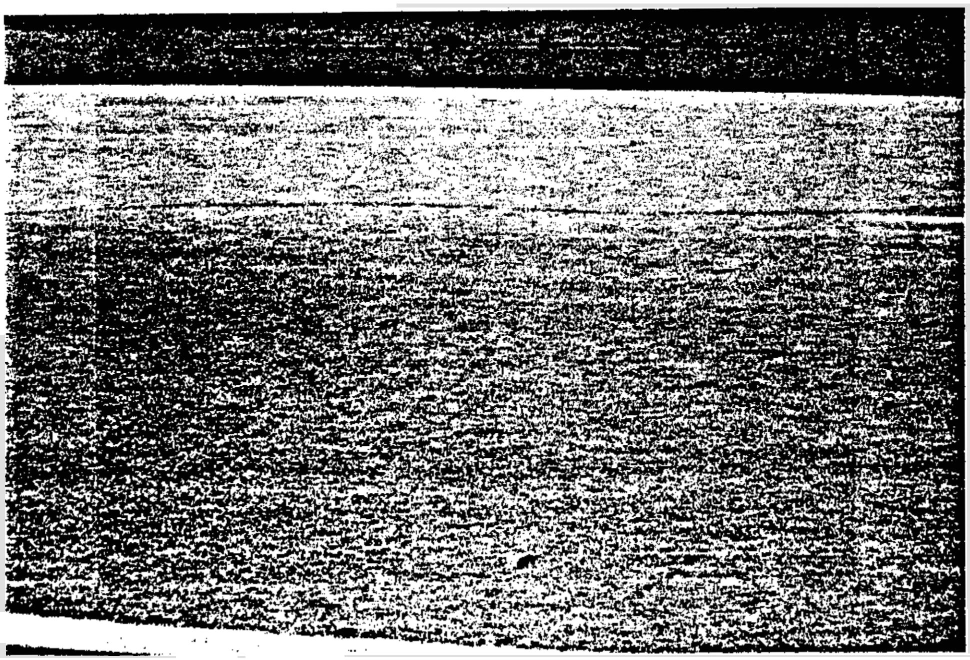
PHOTOGRAPHS

PHOTOGRAPH 10

March 1979

Retrospective View
From Station 977
To Station 981

Pre-existing
Pavement Distress

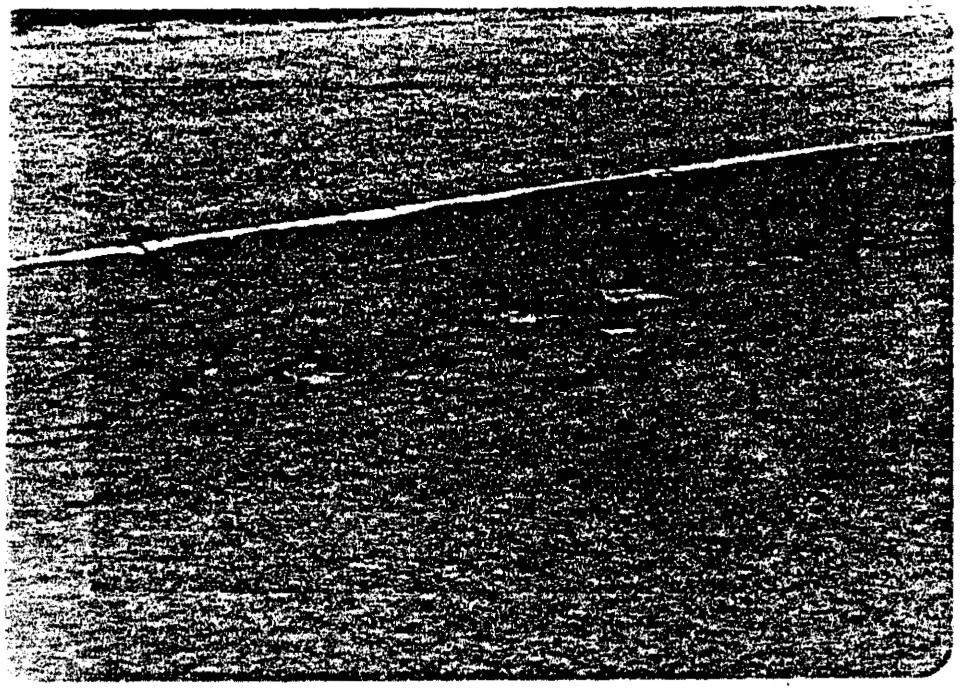


PHOTOGRAPH 11

January 1983

Lateral View
Across Station 981

Comparative View
Of Treated Section

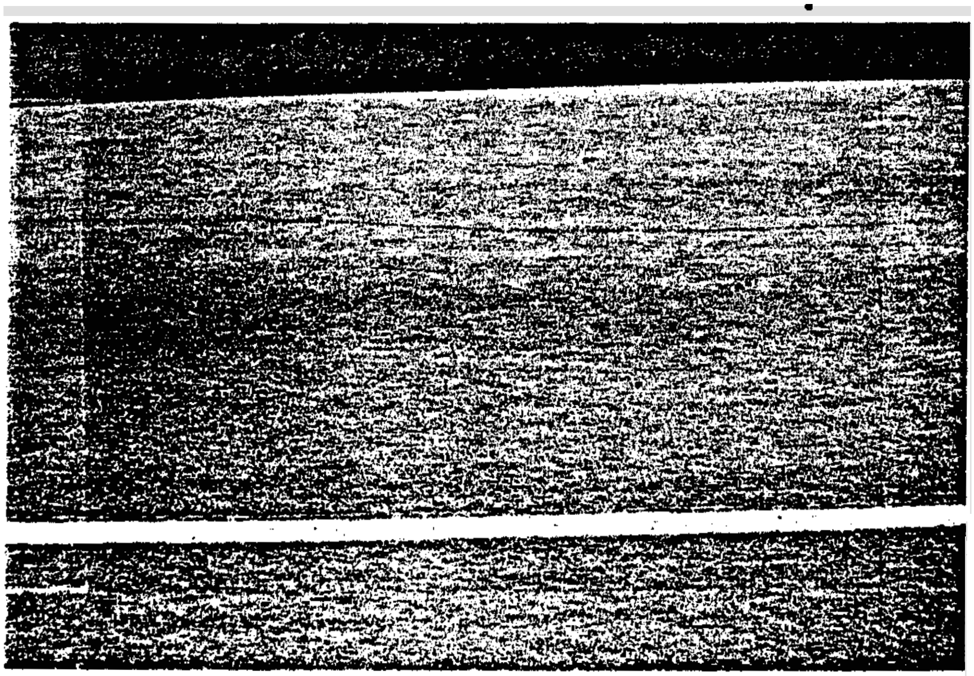


PHOTOGRAPH 12

March 1979

Forward Oblique
View Across
Station 984

Pre-existing
Pavement Distress

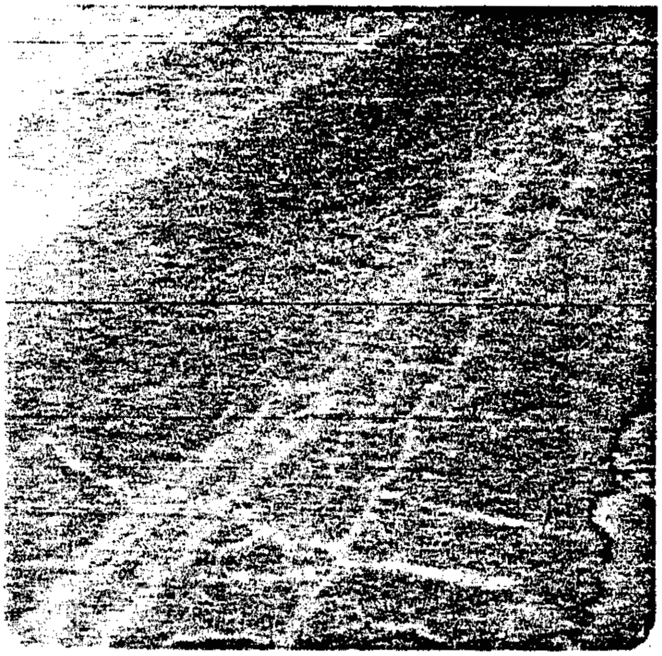


PHOTOGRAPH 13

January 1983

Lateral View Acro
Station 984

Comparative View
Of Treated Sectio

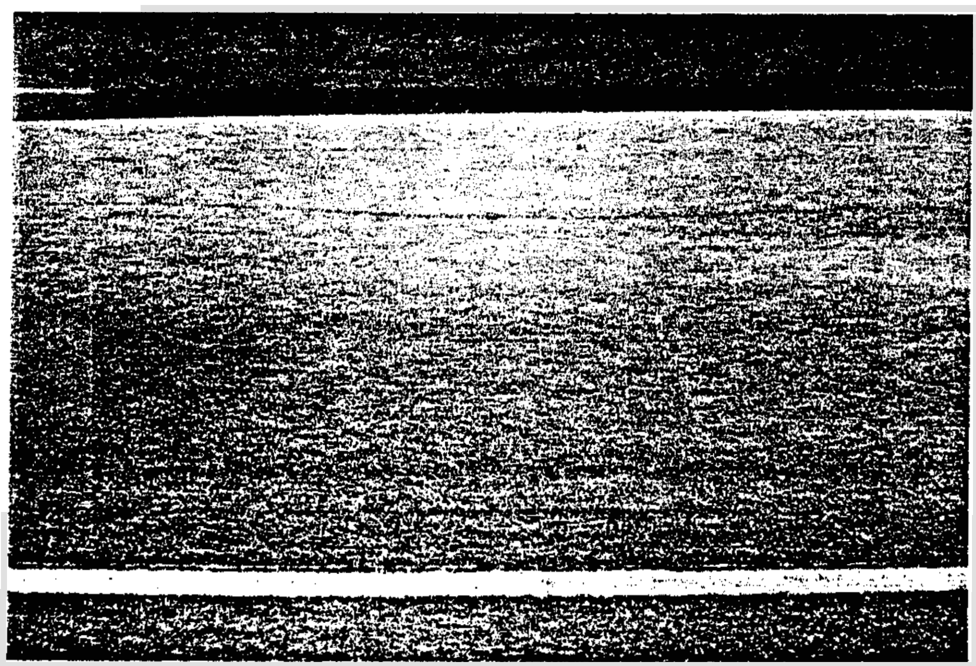


PHOTOGRAPH 14

June 1979

Forward View Onto
Station 1028

Pre-existing Pavement
Distress



PHOTOGRAPH 15

January 1983

Lateral View
Across
Station 1028

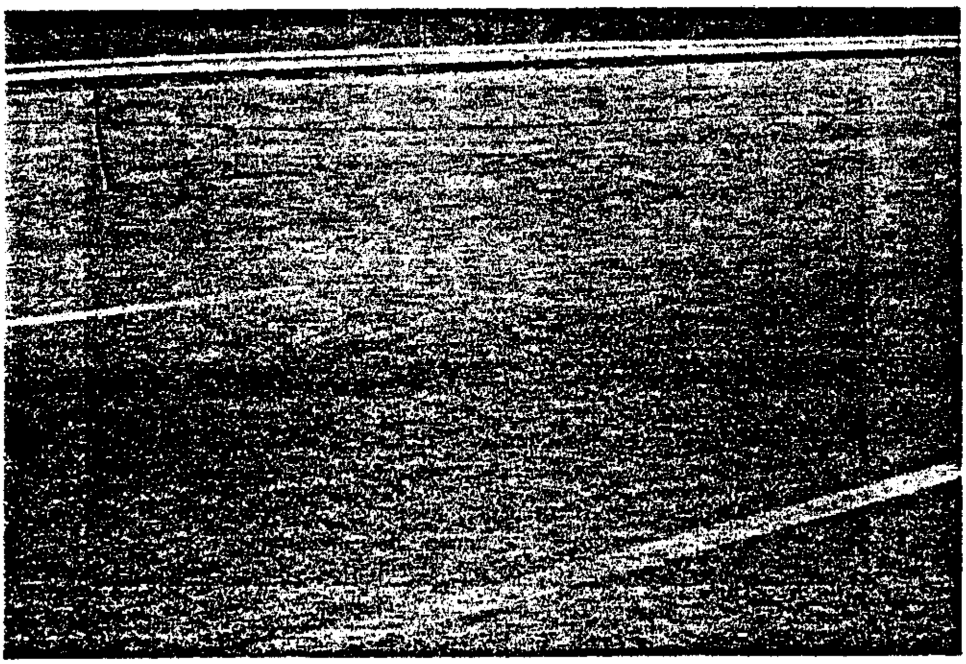
Comparative View
Of Treated Section

PHOTOGRAPH 16

June 1979

Partial Oblique View Across Station 1093

Pre-existing Pavement Distress

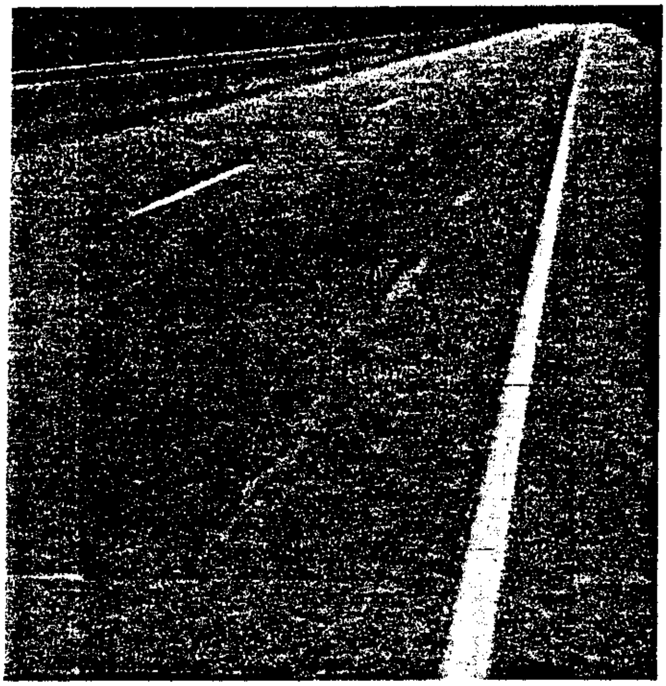


PHOTOGRAPH 17

January 1983

Forward Obliqu
View Across
Station 1093

Comparative Vi
Of Treated Sec



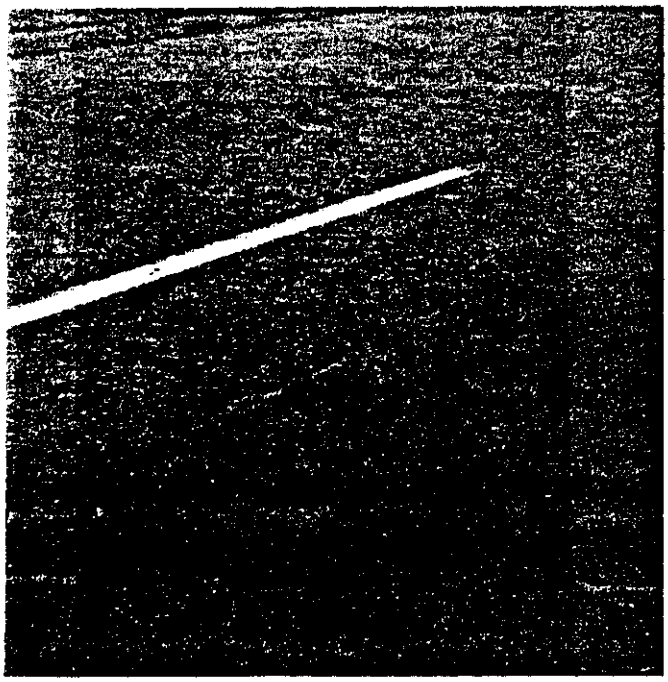
PHOTOGRAPH 18

October 1981

Forward View From
Station 949+30

Early Fatigue Cracking
Through Overlay

Control Section With No
Rubber Asphalt Surface
Treatment



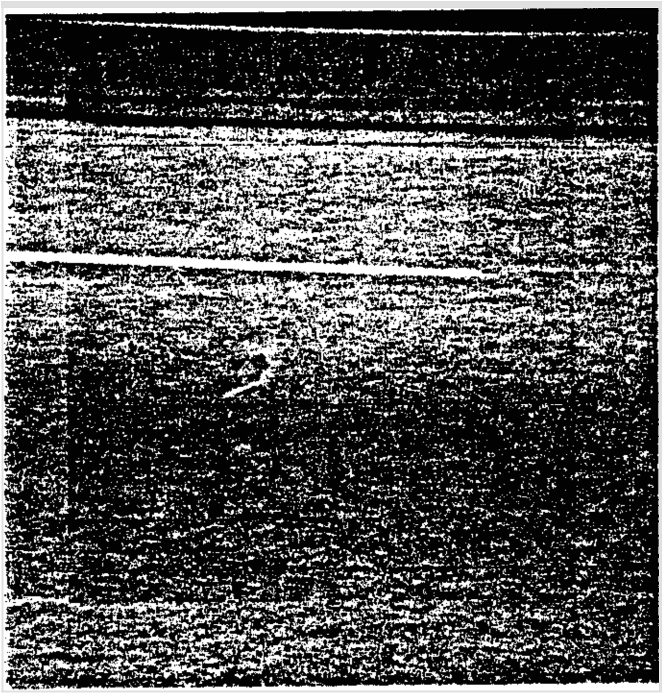
PHOTOGRAPH 19

October 1981

Forward Oblique View
Across Station
950+20

Early Fatigue Cracking
Through Overlay

Control Section With No
Rubber Asphalt Surface
Treatment



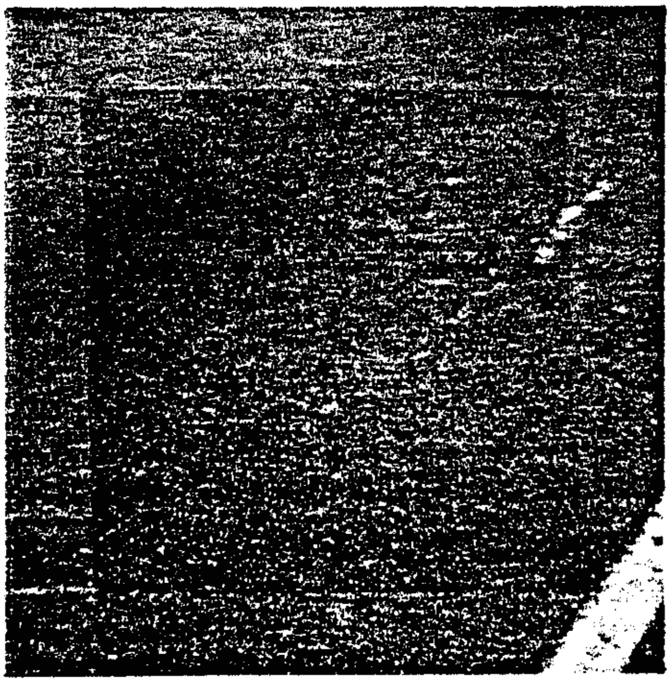
PHOTOGRAPH 20

November 1982

Lateral View Across
Station 1021+50

Early Transverse Cracking
Through Overlay

Treated Section



PHOTOGRAPH 21

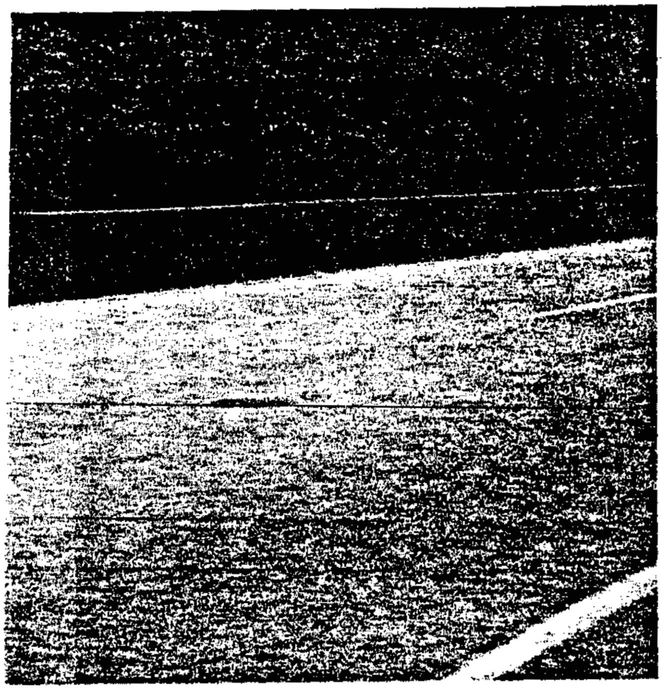
November 1982

Partial Forward Oblique
View Onto Station 1121

Very Early Transverse Crack
Development Through Overlay

Approximate Beginning Of
Control Section

Note
Edgeline



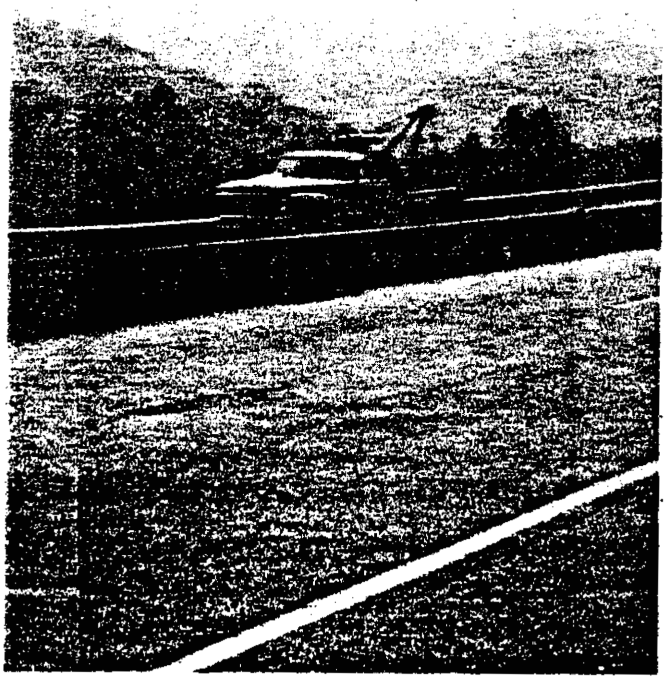
PHOTOGRAPH 22

November 1982

Forward Oblique View
From Station 902+35

Rutting In Overlay

Treated Section



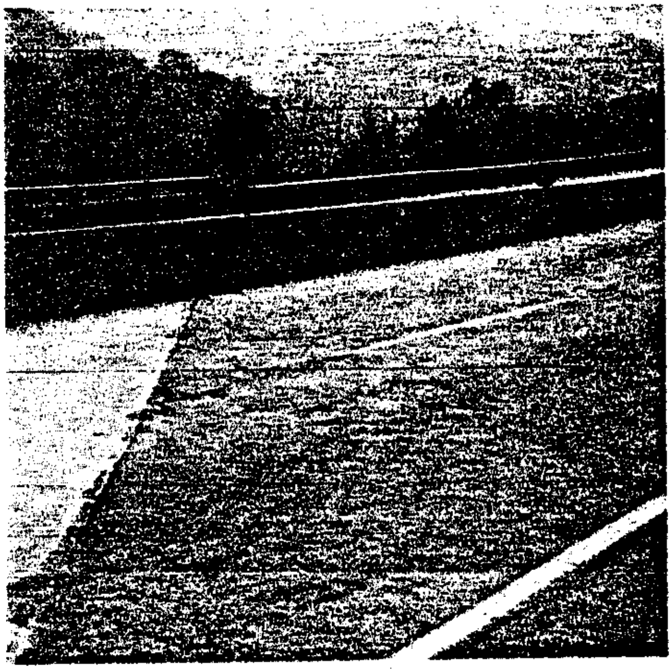
PHOTOGRAPH 23

November 1982

Forward Oblique View
From Station 1050

Rutting In Overlay

Treated Section



PHOTOGRAPH 24

November 1982

View Across Bridge Leave
Section At Station 1049+00

Random Crack Reflections
Through Very Thin Overlay

Treated Section

PHOTOGRAPH 25

November 1982

View Across Bridge Leave
Section At Station 1077+65

Random Crack Reflections
Through Very Thin Overlay

Treated Section

SPECIFICATIONS

FOR

MATERIALS

AND

EQUIPMENT

Cover Material

Aggregate for cover material shall consist of crushed rock or crushed gravel conforming to the requirements of AASHTO Specification T27. The aggregate shall meet the following gradation requirements:

Sieve Size	Percent Passing #6 Stone
1 in.	100
3/4 in.	90-100
1/2 in.	20-55
3/8 in.	0-15
No. 4	0-5
No. 8	-
No. 16	-

The sieves shall comply with the requirements of AASHTO M92 (ASTM E11).

The cover aggregate may be preheated or precoated with 0.5 to 0.75 percent paving grade asphalt.

The contractor shall submit a minimum 75 pound sample of cover material to the engineer for testing at least 10 calendar days prior to the spreading of this material.

Blotter Material

The blotter material shall be a fine aggregate (sand) conforming to the following gradation requirements:

Sieve Size	Percent Passing
3/8 in.	100
No. 4	80-100
No. 16	45-80
No. 50	10-30
No. 100	2-10

The sieves shall comply with the requirements of AASHTO M92 (ASTM E11).

General Equipment Specifications

The equipment used by the contractor shall include a self-propelled rotary power broom for pavement cleaning and excess cover material removal and a self-propelled pressure

Construction Procedures

All of the materials associated with the rubber asphalt stressing absorbing membrane shall be included in a unit pay item "rubber asphalt surface treatment." This includes asphaltic cement, granulated rubber, diluent, cover materials, and blotter materials.

Asphalt

The grade of asphalt cement for the asphalt rubber mixture shall be AC-10. This material shall comply with the applicable requirements of AASHTO M226 and shall also have a maximum penetration of 150 when tested in accordance with AASHTO T49 (ASTM D5). All test provisions of Section 920 of the North Carolina Standard Specifications shall apply.

Rubber Material

The granulated crumb rubber shall be 100 percent vulcanized and meet the following gradation requirements:

Sieve Size	Percent Passing
No. 8	100
No. 10	98-100
No. 30	0-10
No. 40	0-4

The sieves shall comply with the requirements of AASHTO M92 (ASTM E11).

The specific gravity of the material shall be 1.15 ± 0.02 and shall be free from fabric, wire or other contaminating materials, except that up to 4 percent calcium carbonate may be included to prevent the rubber particles from sticking together.

Granulated crumb rubber shall be accepted by certification from the rubber supplier.

Diluent

The diluent shall be a solvent with an initial boiling point (IBP) of 350° and an end point (EP) not exceeding 410°F when tested in accordance with ASTM D86.

some project locations or where production rates dictate, fewer rollers may be utilized as directed by the engineer.

Sufficient rollers shall be used for the initial rolling to cover the width of the aggregate spread with one pass. The first pass shall be made immediately behind the aggregate spreader, and if the spreading is stopped for any reason, the spreader shall be moved ahead or off to the side so that all cover material may be immediately rolled. Four complete passes with rollers shall be made with all rolling completed within 2 hours after the application of the cover material.

Application of Blotter Material

Blotter material may be required immediately after the initial pass of the rollers (usually 4 to 6 pounds per square yard) or after opening to traffic and sweeping so as to prevent asphalt-rubber bleed through and pick-up. The use, rate, and locations for blotter material shall be designated by the engineer. The blotter material shall be uniformly applied using either a hopper or whirl-type tailgate spreader.

At the time of application, the blotter material shall be at least as dry as material dried in accordance with the requirements of AASHTO T-84.

Traffic Control

Traffic shall be directed through the project with warning signs, cones, and flagmen in a manner that provides maximum safety for the workmen and the least interruption of the work.

Except when it is necessary for hauling equipment to travel on the newly applied membrane, traffic of all types shall be kept off the membrane until it has had time to set properly. The speed of all hauling equipment shall not exceed 15 miles per hour when traveling over a membrane which is not adequately set. The minimum traffic free period shall not be less than two hours.

Removing Loose Cover Material

The sweeping shall be a multi-step operation following placement of the membrane. The initial sweeping shall be a light brooming at the end of the placement day with a second sweeping completed at daybreak of the day following membrane placement. If because of high temperatures or other causes there is dislodgment of cover material, sweeping shall be discontinued until such time as there will be satisfactory retention of cover material.

material shall not be reheated to temperatures above 325°F. Additional diluent up to a maximum of 3 percent by volume of the hot asphalt-rubber mixture may be used after reheating of the material.

Application of Asphalt-Rubber Material

Placement of the asphalt-rubber shall be made only under the following conditions:

(1) The pavement surface temperature is not less than 50°F and rain is not imminent.

(2) The pavement surface is clean and absolutely dry.

(3) The wind conditions are such that excessive blowing of the spray bar fans is not occurring.

(4) All construction equipment such as asphalt-rubber distributor, aggregate spreader, haul trucks with cover material, and rollers are in position and ready to commence placement operations.

The asphalt-rubber mixture shall be applied at a temperature of not less than 325°F at a rate of .55 to .70 gallon per square yard (based on 7 1/2 pounds per hot gallon). Transverse joints shall be constructed by placing building paper across and over the end of the previous asphalt-rubber application. Once the spraying has progressed beyond the paper, the paper shall be removed immediately and disposed of as directed by the engineer. All longitudinal joints shall be lapped a minimum of 4 inches if deemed necessary by the engineer.

Application of Cover Material

Cover material shall be applied immediately to the asphalt-rubber after spreading at a rate of 30 to 40 pounds per square yard unless as otherwise instructed by the engineer.

At the time of application to the asphalt rubber, cover material shall be at least as dry as material dried in accordance with the requirements of AASHTO T-85.

Rolling

At least 2 pneumatic-tired rollers shall be provided to accomplish the required embedment of the cover material. At asphalt distributor capable of applying tack coat uniformly at the specified rate. If a blotter material (sand) is to be applied, a hopper or whirl-type tailgate spreader shall be required.

Asphalt-Rubber Equipment

All equipment utilized in processing and application of the asphalt-rubber material shall be as described below:

(1) A truck or trailer mounted self-powered distributor equipped with a heating unit, a mixing unit capable of producing a homogeneous mixture of asphalt and rubber, pump(s) capable of spraying asphalt-rubber within ±0.10 gallon per square yard of the specified rate, and a fully circulating spray bar capable of applying asphalt-rubber without a streaked or otherwise irregular pattern.

(2) The distributor also shall include a tachometer, pressure gauges, volume measuring devices, an onboard weighing device to aid in proportioning materials and a thermometer. A "bootman" shall accompany the distributor and ride in a position so that all spray bar nozzles are in his full view and readily accessible for unplugging.

Cover Material Spreader

The cover material (chip) spreader shall be a self-propelled machine with an aggregate receiving hopper in the rear, belt conveyors to carry the aggregate to the front, and a spreading hopper equipped with full-width distribution auger and spread roll. The spreader shall be in good mechanical condition and be capable of applying the cover material uniformly across the spread at the specified rate.

Rolling Equipment

Self-propelled pneumatic-tired rollers shall be used for the required rolling of the cover material. The pneumatic-tired rollers shall carry a minimum loading of 5,000 pounds on each wheel and an air pressure of 100±5 pounds per square inch in each tire.

Hauling Equipment

Trucks for hauling cover material shall be tailgate discharge and shall be equipped with a device to lock onto the hitch at the rear of the aggregate spreader. Haul trucks shall also be compatible with the aggregate spreader so that the dump bed will not push down on the spreader when fully raised or have too short a bed which results in aggregate spillage while dumping into the receiving hopper.

General Construction Details

Holes and depressions in the old pavement surfacing shall be repaired by patching if deemed necessary by the engineer. Provision shall also be made for the use of a tack coat of RS-1H asphalt if deemed necessary by the engineer.

Tack Coat

The tack coat shall be applied to the cleaned surface and allowed to fully cure before spreading of the asphalt rubber material. The temperature range will be 90°-150°F.

Asphalt-Rubber Material Mixing

The percentage of crumb vulcanized rubber shall be 33 1/3 ± 2 percent by weight of the asphalt cement.

The temperature of the asphalt shall be between 350°F and 395°F before addition of the crumb vulcanized rubber. The materials shall be carefully combined and mixed and reacted for a period of time as required by the engineer which shall be based on laboratory testing by the asphalt-rubber supplier or contracting agency. The temperature of the asphalt rubber mixture shall be above 325°F during the reaction period.

After the reaction between asphalt and rubber has occurred, the viscosity of the hot asphalt-rubber mixture may be adjusted for spraying or better "wetting" of the cover material by the addition of a diluent. The diluent shall not exceed 7 1/2 percent by volume of the hot asphalt-rubber mixture.

If a job delay results after the full reaction has occurred, the material may be allowed to cool and be slowly reheated to an acceptable spraying temperature just prior to application. However, because of the polymer reversion that can occur when crumb rubber is held for prolonged high temperatures, the

Placement of Asphalt Concrete

The placement of the asphalt concrete overlay shall be delayed as directed by the engineer for sufficient time to allow for adequate evaporation of the diluent.

If the rubberized membrane has been subjected to traffic, a CRS-1H asphalt tack coat shall be applied prior to overlaying.

Method of Measurement and Basis of Payment

Payment will be made on the basis of per square yard of "rubber asphalt surface treatment."

FACT SHEET

Project Description: North Carolina Department of Transportation Stress Absorbing Membrane Interlayer For Bituminous Concrete Pavement Rehabilitation

Project Location: Interstate Highway 40 Eastbound Lanes From Fines Creek to US Highway 276 in Haywood County, North Carolina, a Distance of Approximately 5.6 Miles

Date Of Project Reconstruction: August 1979

Date of Original Pavement Construction: 1968

Pavement Rehabilitation Treatment: The original pavement construction consisted of three composite layers of conventional materials - fourteen inches of aggregate base course, three inches of bituminous concrete binder, and two inches of bituminous concrete surface course. In eleven years of exposure to interstate type traffic conditions and to moderately severe environmental conditions, the original pavement surface had succombed to severe, physical fatigue distress. Major pavement rehabilitation measures were necessary to restore adequate and safe serviceability to the pavement. The pavement rehabilitation measures consisted of a vulcanized rubber asphalt surface treatment stress absorbing membrane, a one and one half inch bituminous concrete binder course, and a one inch bituminous concrete surface course. The rubber asphalt membrane was placed directly atop the original pavement surface. The membrane consisted of a rubber asphalt spray at the rate of approximately .60 gallon per square yard of surface and a large stone mat applied at a coverage rate of approximately 40 pounds per square yard rolled into place.

Serviceablilty Indications: The composite pavement rehabilitation treatment provided excellent serviceability for a period of three and one half years. The first signs of reflective fatigue distress appeared during February 1983. The highway section received a one inch bituminous concrete surface course overlay in September 1985. The reconstructed pavement has remained in excellent condition during 1986.

Cost of Rehabilitation Project: The total cost of the pavement rehabilitation project was $525,000. Of this total cost, approximately $123,350 was for the construction of the rubber asphalt surface treatment stress absorbing membrane (49,340 square yards @ $2.50 per square yard bid price).

NU-TECH SYSTEMS, INC.

PRESENTS THE

NU-TECH PYRO-MATIC RESOURCE RECOVERY SYSTEM

The Pyro-Matic Resource Recovery System has been conceived, designed and constructed to make the pyrolysis of tires and other materials economically viable. The basic parameters of good product design were fully exploited to evolve a pyrolysis system composed of thoroughly proven, heavy duty components integrated in the most simple arrangement to achieve maximum dependability for around-the-clock service with minimum maintenance requirements.

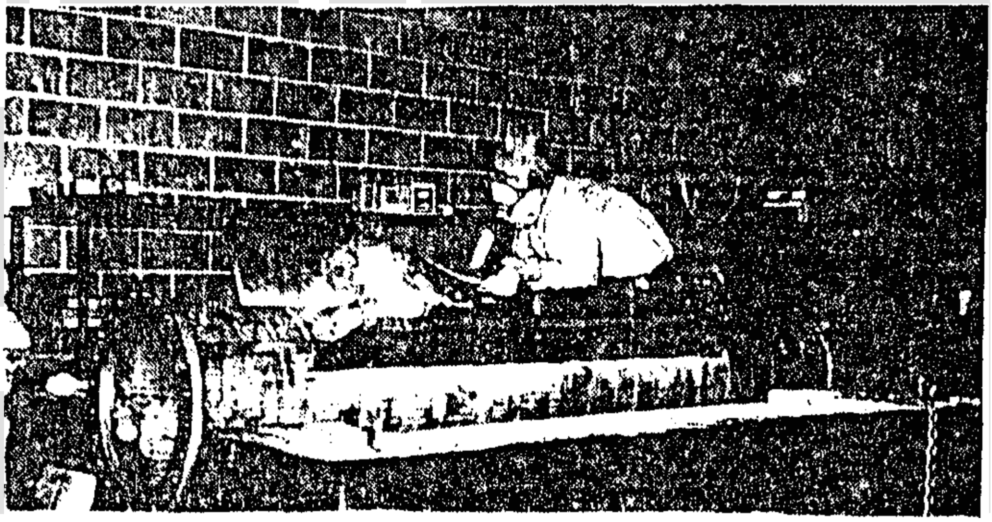
The same philosophy has been applied in the design of the control system and while "state of the art" components are used throughout the control system, these are thoroughly proven components selected for exceptional dependability.

The Pyro-matic Resource Recovery System achieves the highest level ever for simplicity of operation, dependability and consistency of high quality pyrolysis product.

PYRO-MATIC DESIGN AND CONSTRUCTION FEATURES

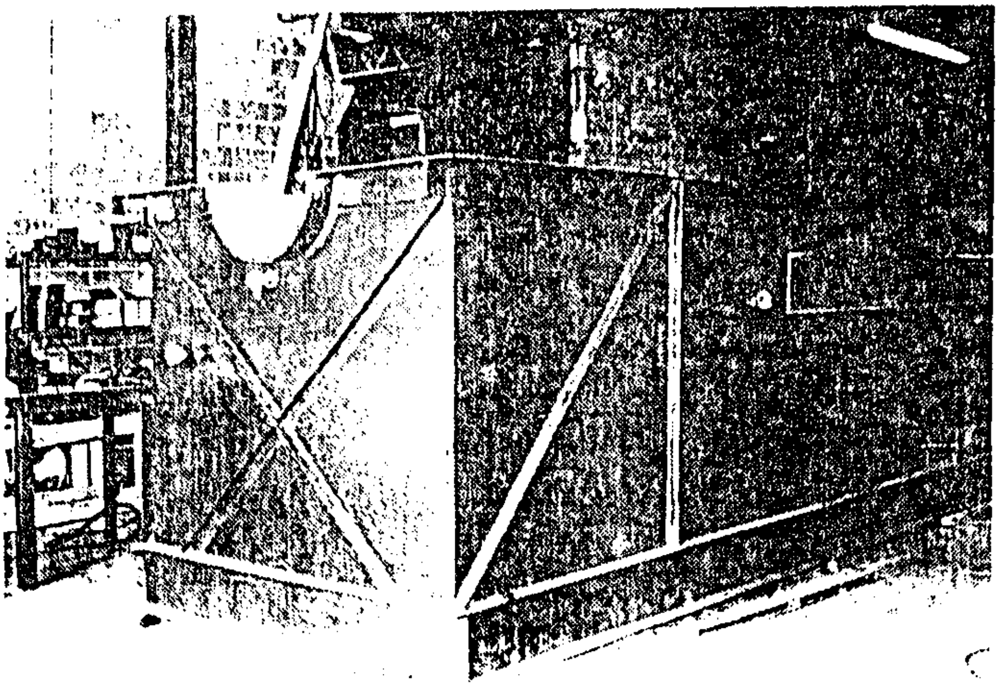
The heart of the Pyro-matic is the special stainless steel alloy reaction chamber which is mounted in a furnace box.

The wall of the reaction chamber is a full one-inch thick and heavily reinforced with stiffeners to prevent sagging or distortion under the most extreme temperature conditions.

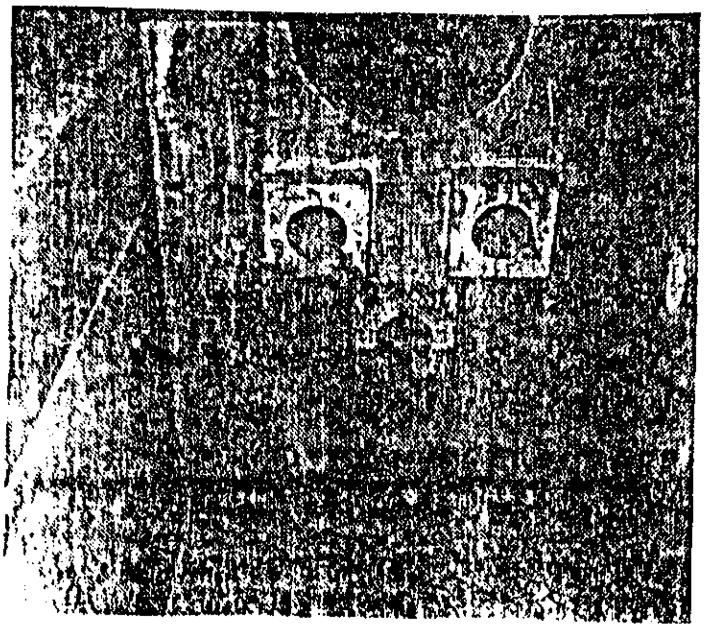


All flanges of the complete reactor tube assembly are machined after welding to assure a perfect seal with minimum use of high temperature liquid gasketing.

The furnace box is fabricated of one-half inch steel plate and consists of two sections which mate at the longitudinal center-line of the reactor chamber. A heavy channel steel frame assembly is an integral part of the lower furnace box section and provides solid support for the external end of the reactor tube, burner assemblies and other components.



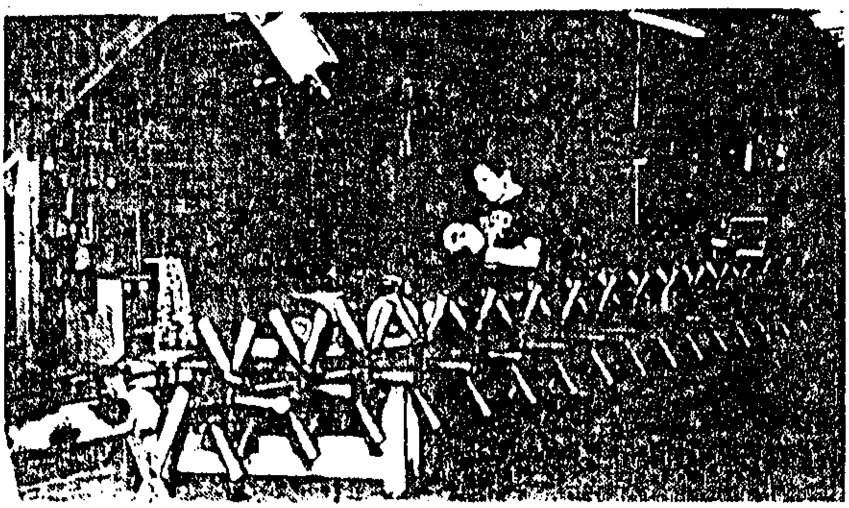
The interior of the furnace box is lined with refractory blocks followed by a heavy thickness of castable refractory. All refractory materials are of the highest quality formulated for this specific application. The furnace box is designed to accommodate three burners for even heat distribution and to permit servicing of a burner without interrupting production.



REACTOR CHAMBER FUNCTIONS

The Pyro-Matic's Reactor Chamber is so called because, along with auxiliary components, it provides functions beyond that of a simple retort. The basic Reactor Chamber consists of three flanged tubes which are bolted together. The center tube is mounted within the furnace box and the other two tube sections which are bolted to the center tube are external of the furnace box. One of the external tubes is equipped to permit introduction of feedstock material as well as discharge of oil-ladened vapor gas. The other external tube section permits removal of carbon black to a cooling, conveying and collection station. Both external tubes are equipped with pressure relief valves.

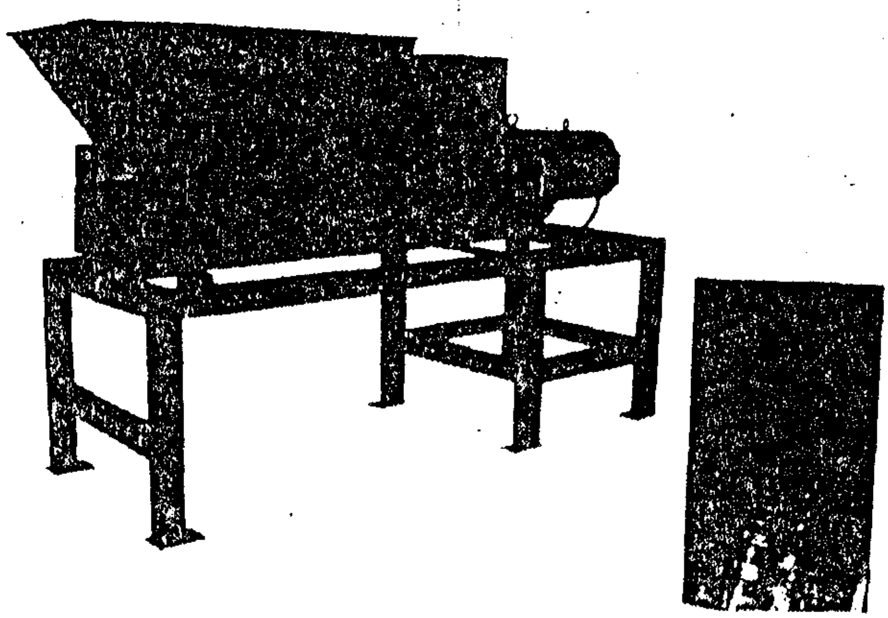
A heavy duty shaft with agitator-transport pins fabricated around the shaft in a helical pattern runs the entire length of the reactor tube assembly.



The control system permits any combination of forward-reverse cycling of the shaft to precisely control retention time while providing constant agitation of the feedstock material to assure a consistant high quality pyrolysis product.

MATERIAL PREPARATION AND DELIVERY SYSTEM

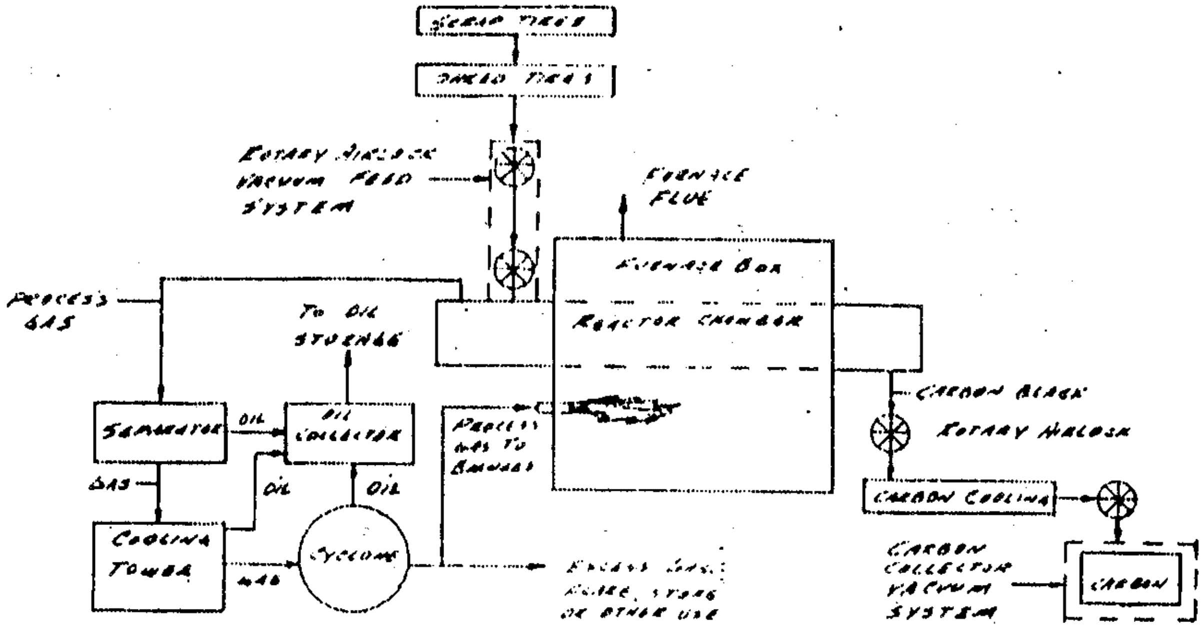
A significant factor in achieving an economically viable operation yielding high quality pyrolysis products begins with proper preparation of the feedstock. Low-speed high-torque shredders such as manufatured by the Shred Pax Corporation are ideal for reducing tires to a particle size of approximately one to one and one half inches square which optimizes every aspect of the pyrolysis operation including feedstock handling, pyrolyzing efficiency and consistency of quality. These shredders are equally effective for other types of pyrolysis feedstock materials such as insulated wire, lead acid batteries, x-ray film and other materials.



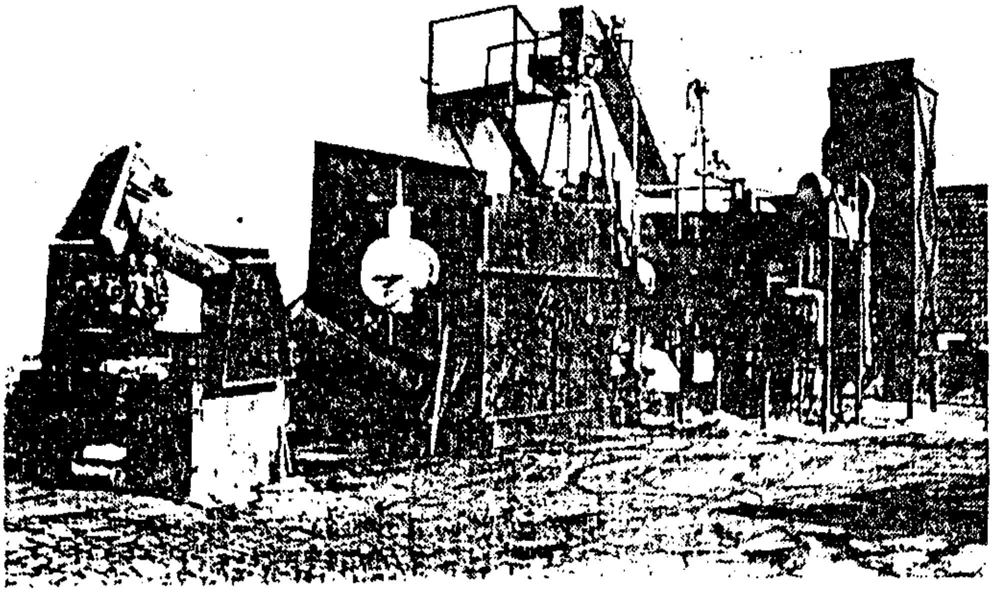
One method of delivers feedstock to the Pyro-matic consists of a shredding system mounted above a receiving hopper. The receiving hopper is equipped with a variable-rate vibratory feeder to deliver the shredded material at the desired rate to a cleated conveyor belt which serves the reactor chamber's feedstock inlet system.

FLOW DIAGRAM

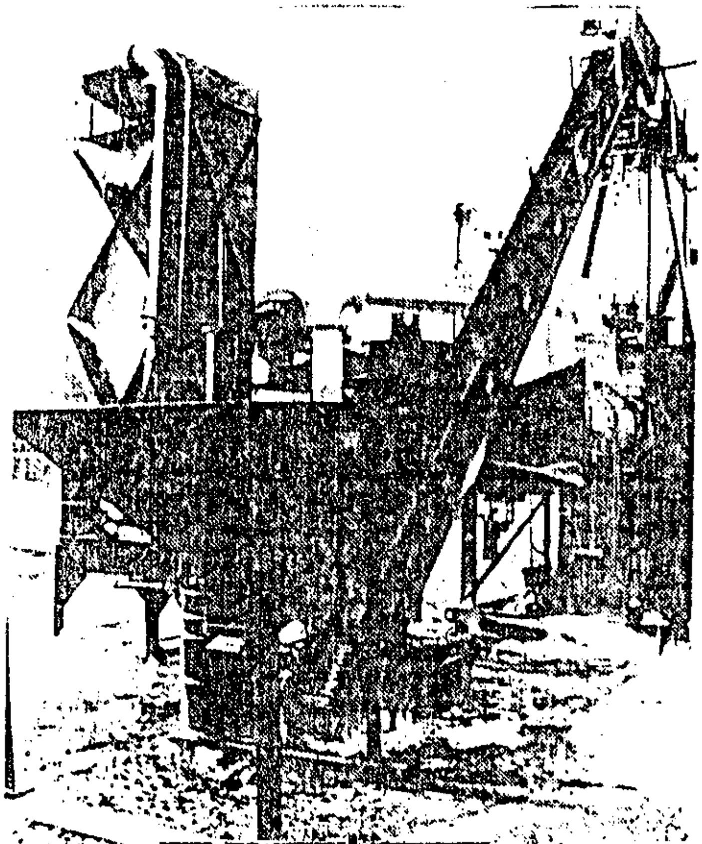
NU-TECH PYRO-MATIC RESOURCE RECOVERY SYSTEM



A Pyro-Matic Resource Recovery System has been installed at the Nu-Tech facility in Bensenville, Illinois, and is in frequent operation for demonstration purposes. Natural gas under normal utility residential service pressure is used to bring the system to pyrolyzing temperature at which time feedstock is introduced. Within approximately 30 minutes or less the system can be switched to the process gas produced from the feedstock.

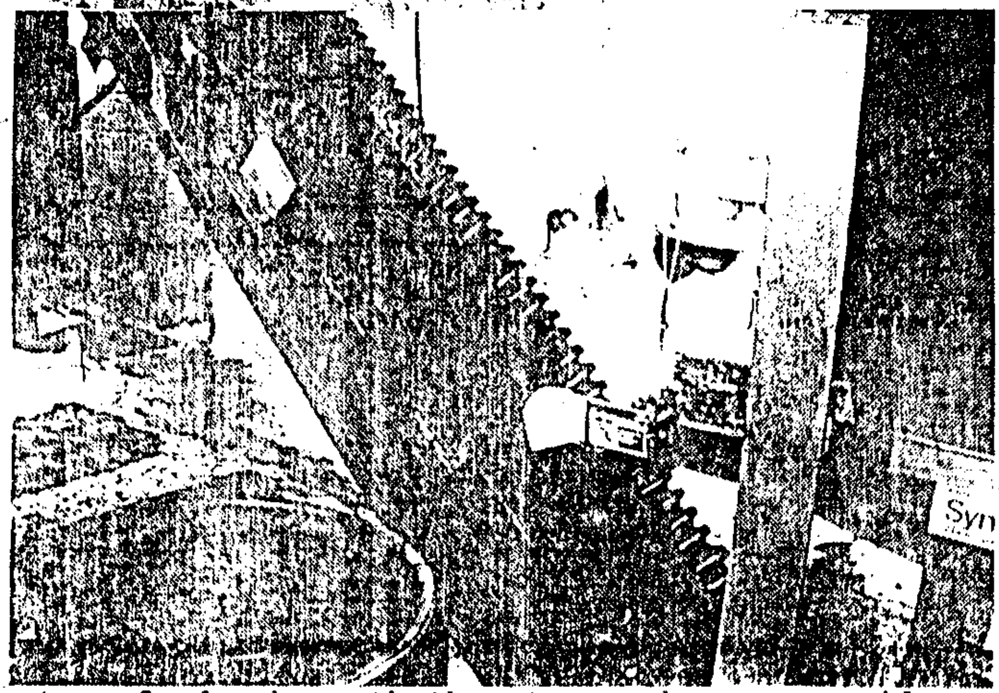


The Pyro-Matic system installed at Nu-Tech functions according to the Flow Diagram illustrated on page 6 with the single exception that the Shredding system had not been installed above the feedstock storage hopper at the time these illustrations were photographed. The system above as viewed from left to right consists of the carbon collection chambers, jacketed water-cooled carbon conveyor, furnace box containing 24" diameter reactor chamber, material feed conveyor and controlled feed inlet and oil collection system.

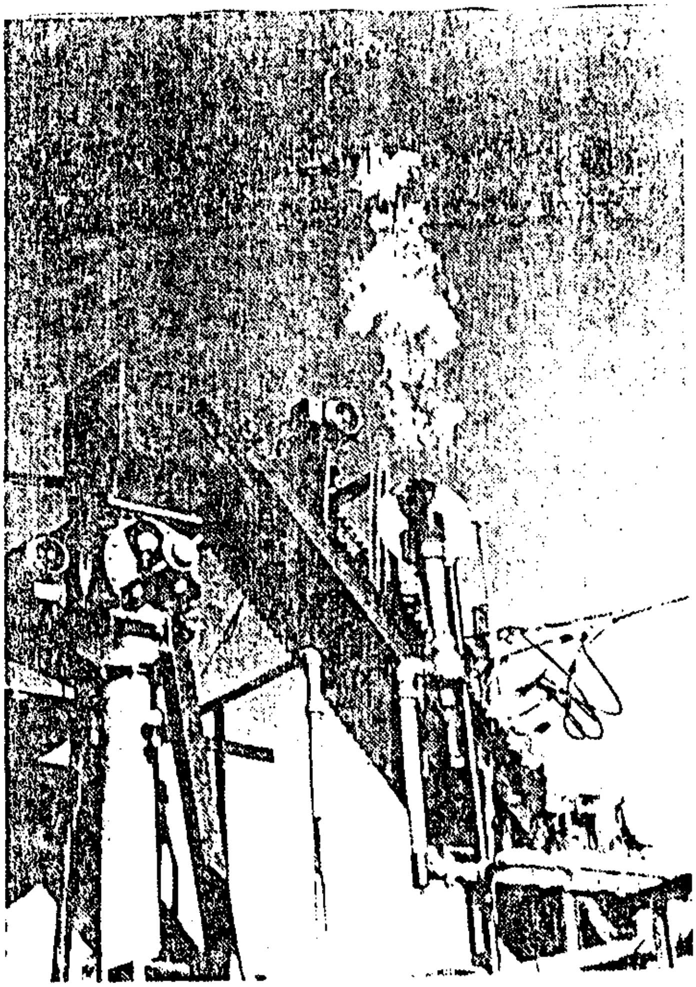


NOTE: The Pyro-Matic system is not a permanent installation at the Nu-Tech facility and consequently loose, temporary wiring appears throughout this series of photographs.

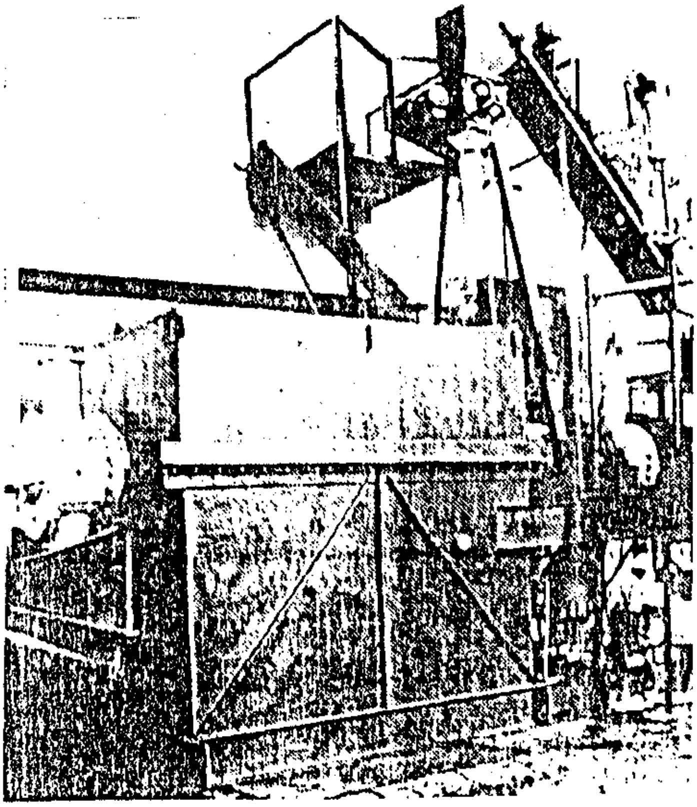
A cleated conveyor belt provides exceptional dependability and trouble-free operation for delivering feedstock to the reactor. The storage hopper can be provided in configurations for specific requirements including the installation of a Shred Pax shredding system directly above the hopper to minimize and simplify material handling.



A vibratory feeder beneath the storage hopper provides positive, uniform feeding of material to the cleated conveyor belt. Feed rate is controlled with a simple dial adjustment. This simple but highly effective material handling method has been thoroughly proven in countless applications.

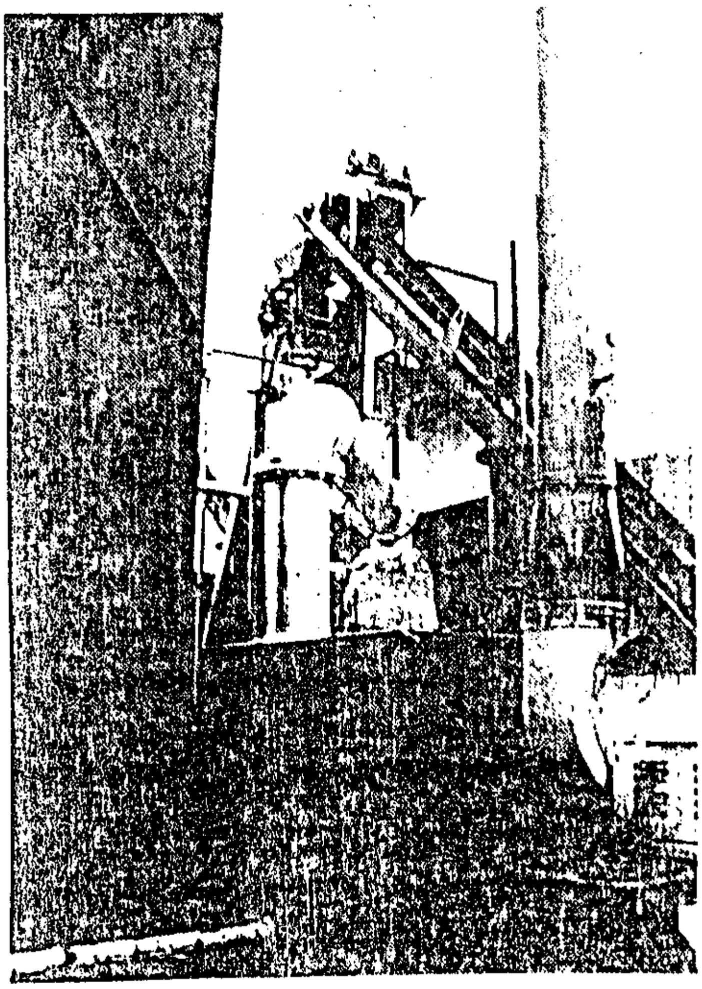


The reactor feed system operates under its own vacuum system and consists of a vertical pipe with rotary air locks at top and bottom as well as high and low level sensors. When the feed pipe empties, the low level sensor stops the bottom air lock. When the feedstock reaches the upper sensor, the top air lock stops and the bottom air lock is actuated to feed material into the reactor. This, along with the vacuum system minimizes the possibility of oxygen entering the reactor. This view also shows excess manufactured gas being flared.

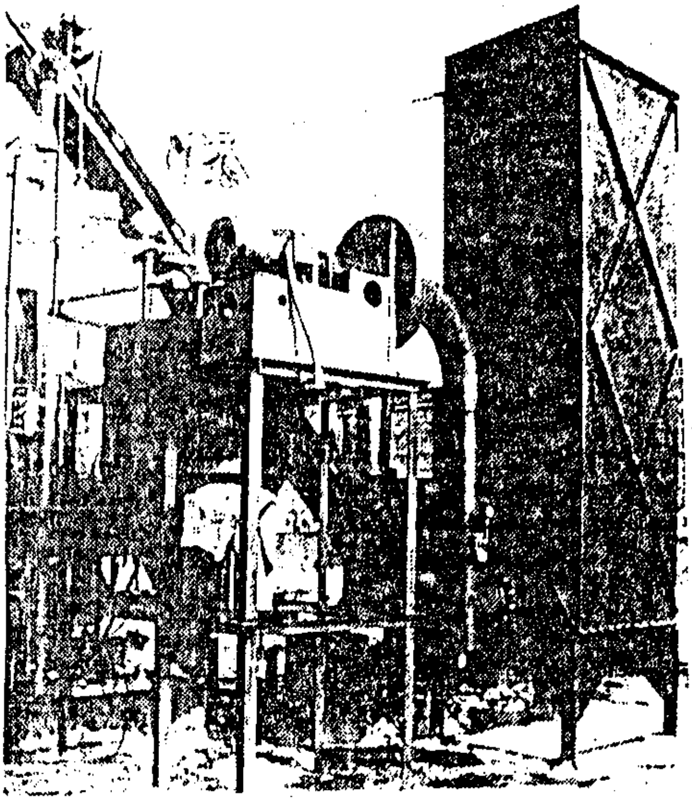


The furnace box in which the reactor chamber is mounted is constructed of 1/2" steel heavily reinforced to eliminat distortion. The furnace box i lined with blocks and castable refractory of the highest quality.

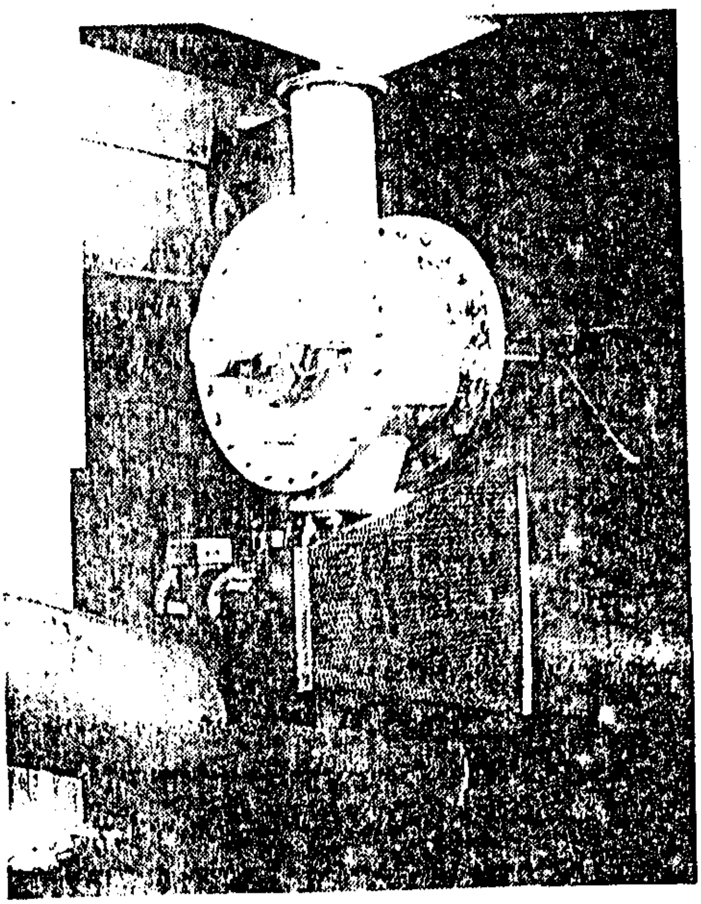
The furnace box is provided with three burners for even heat distribution and to provide a margin of dependability in the event that a burner requires service.



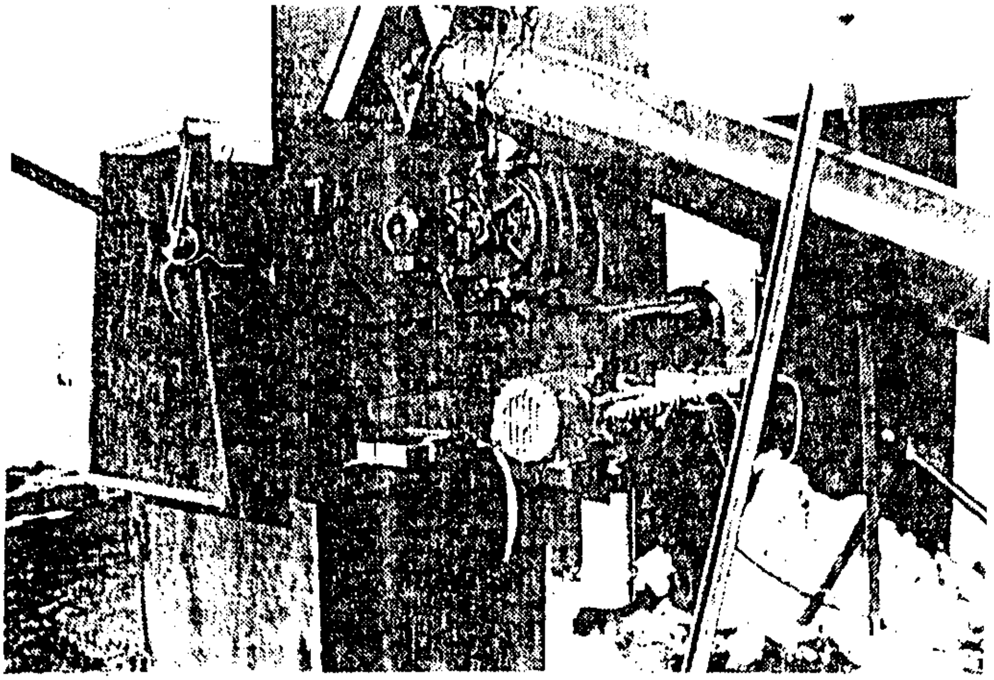
Process gas is transfered from the reactor chamber to a separator which is seen in the lower foreground while the cooling tower is at the left. Both the gas transfer pipe and separator are equipped with pressure relief valves.



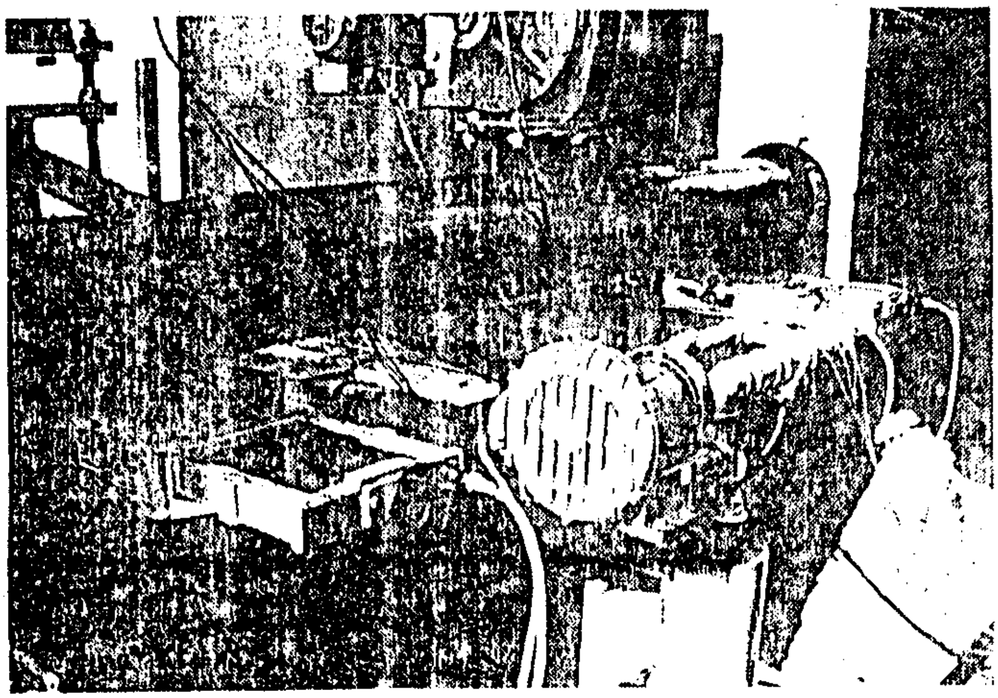
The oil collection system consists of a separator, cooling tower, cyclone and central collection tank to achieve maximum oil extraction and provide exceptionally clean manufactured gas.



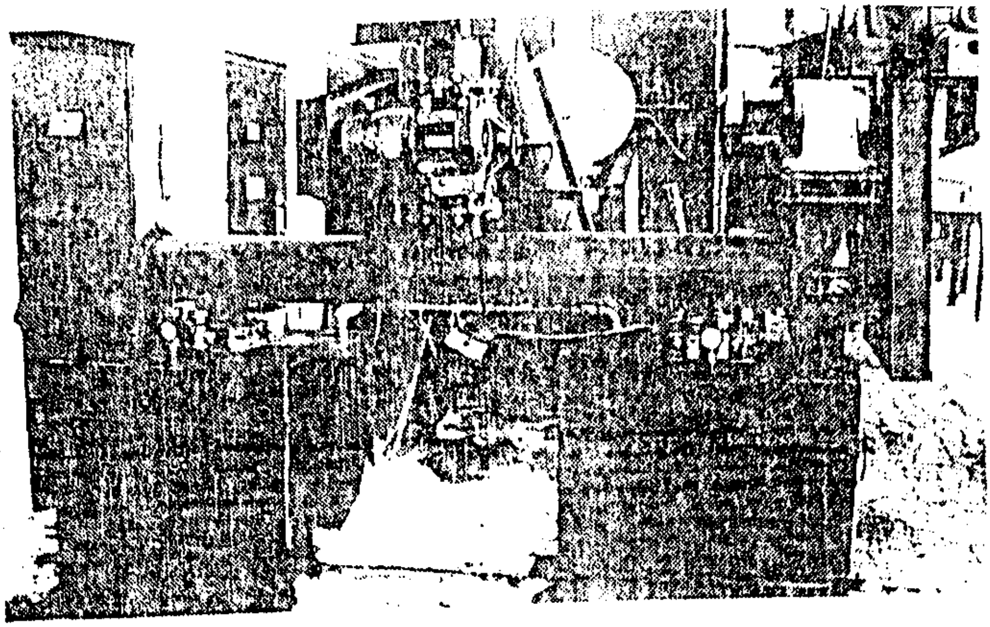
A heavy duty rotary air lock at the inlet of the jacketed water cooled carbon conveyor provides additional protection against oxygen entering the reactor chamber. The reactor chamber is provided with pressure relief valves, one of which is seen here mounted on top of the reactor chamber.



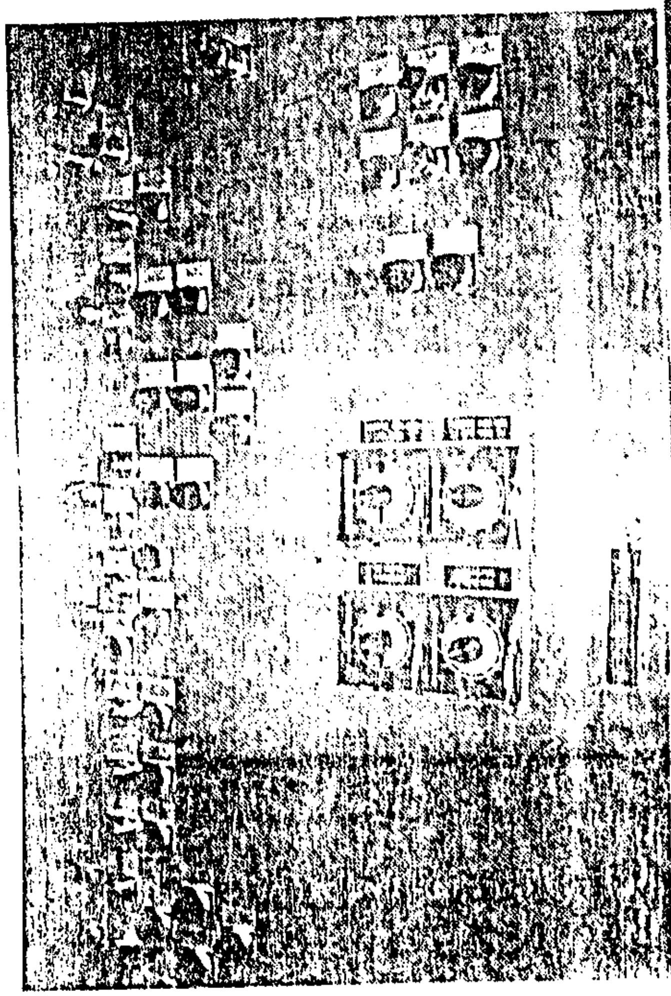
Cooled carbon transported by the jacketed conveyor is delivered to the reversing screw conveyor through a rotary air lock to aid in maintaining an oxygen free atmosphere in the reactor to achieve maximum carbon quality.

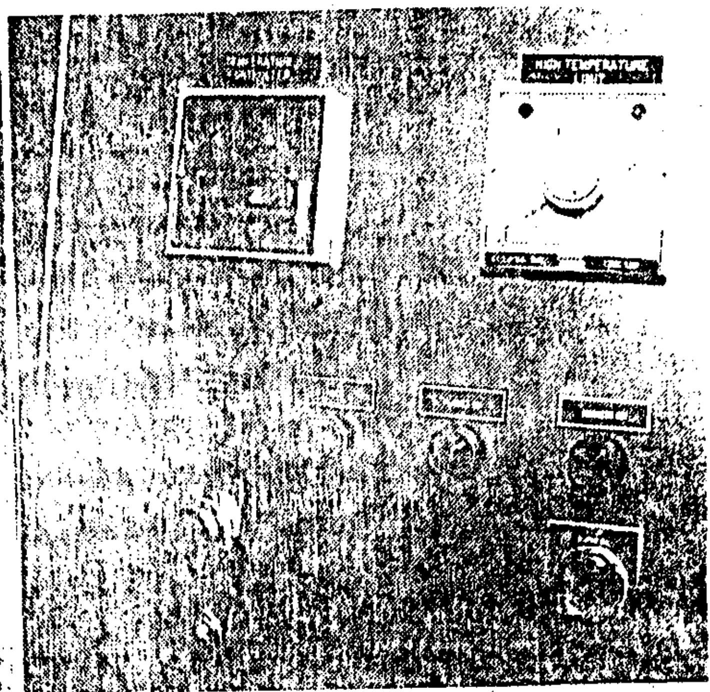


An individual vacuum system and precision slide gates assure vacuum integrity in the carbon collection chambers.



Reversing screw conveyor alternately delivers cooled carbon to chambers. The chamber receiving carbon is maintained under vacuum while the other one may be opened and a tote box containing the carbon is removed by lift truck. Other methods are available for carbon removal.





A simple control system provides automatic operation with monitoring lights to show system status as well as permitting manual operation of various functions.

TIRE DISPOSAL AS A NATIONAL AND PUBLIC ISSUE
FAYETTEVILLE, NORTH CAROLINA
NOVEMBER 13, 1986

MARK W. HOPE
WASTE RECOVERY, INC.

Overview

I need not tell you, for those of you who have experienced either tire fires and/or illegal tire dumping know perhaps better than anyone, that the time has come to find positive and permanent solutions to the problems historically presented by disposal of scrap tires. Legislation which attempts to solve these problems has been passed in two states, is being studied in many others, and to the lesser degree by the Federal Government. I am here to discuss with you some of the opinions I have developed on this matter as a result of my experience with scrap tire recycling and with state programs around the country. I am also here to listen hard to any new ideas or different points of view you may generously be willing to share with me. This problem will take all the creativity we can collectively bring to bear on it to arrive at solutions representing the greatest good for everyone concerned.

The tires we are concerned with here are either used or manufacturers' rejects, and have no further value in their current form. These scrap tires must either be processed to produce a product of value, or sent to proper disposal sites. The range of recycling practices currently employed includes recovery of materials and energy, and use whole tires for retreads and for building artificial reefs, docks, bumpers and erosion control. However, of the approximately 160 million passenger scrap tires generated annually, roughly 70% are either landfilled, stockpiled or randomly dumped.

Studies of scrap tire disposal as far back as the late 1960's and early 1970's documented problems. These included interference with proper landfill operation because of tires' resistance to compaction, and their tendency to work their way back to the surface time and again; mosquito-borne encephalitis resulting from mosquitos breeding in water-filled tires; and invasions of public and private land and creation of eyesores by unscrupulous tire-haulers; and long-burning, air and water polluting fires in stockpiles.

If these problems have been so serious and so long-standing, a reasonable person might ask, why so little action until now to solve them?

An historic perspective on past disposal practices can lead to a greater understanding of how proper disposal* of scrap tires by both consumers and industry has become an environmental priority.

* The term disposal from this point on will generally include the concept of recovery unless landfilling is specified.

State and local governments have historically neglected the development of scrap tire disposal options for at least three reasons:

(1) The "Tire Jockeys" who collect scrap tires are usually small, unorganized entrepreneurs who have been difficult to identify, let alone regulate.

(2) Scrap tires comprise less than 1% of the total municipal waste stream. Other, more significant quantities of waste have received a higher priority since they have a greater potential for immediate negative environmental impacts than tires (e.g. putrefaction, vermin, water pollution, odor).

(3) Tires are more expensive to process for proper disposal per unit than other wastes.

But several factors are currently working to offset these conditions. The first is the fact that landfilling tires is becoming less of an option. Because of the havoc they wreak on landfill operations, and because of the increasing shortage of landfill space, especially in urban areas, many municipal landfills around the country either refuse to accept scrap tires, or they charge a premium for their disposal. Greater emphasis on recycling and waste reduction have added to the pressure to restrict or prohibit the landfilling option, intensifying the need to develop acceptable alternatives.

In addition, recent nationally publicized tire fires on the east (Virginia) and west (Washington) coasts have brought pressure from both the regulatory and political communities to address the stockpiling and random dumping of tires.

That the environmental consciousness of the 1970's and 80's has caught up with scrap tire disposal, elevating it to the status of a local - even a national concern is appropriate. It is in keeping with an increased focus on the individual's impact on the environment, in addition to the more traditional concern about industries' responsibilities. For, although tire dealers have assumed the responsibility of disposing of their current customers' discarded tires, these great lumps of rubber are basically a consumer-generated waste, and are accordingly taxed at the consumer level to provide for regulation of disposal in at least two states. Several other states have proposed or considered legislation in this vein, while still others are attempting to place the responsibility for tax generation on industry rather than at the retail level.

The fact that dealers currently collect most of the tires provides a real opportunity to control where tires will go, once a community decides what their fate will be. Such a "source separation" system is not in place for most other categories of waste, and bodes well for the ultimate successful solution of tire-related problems. The key to success will lie in establishing systems which nurture this existing network, encouraging dealers to continue as collection points, while raising revenues to provide the necessary disposal options.

Environmental Concerns

Although scrap tires or scrap tire stockpiles may be eyesores, they do not pose an immediate threat to the environment unless water or fire are added. Water collecting in the tires provides an ideal habitat for mosquitos, which may carry a disease called LaCross Encephalitis and communicate it to humans. Although direct correlations between mosquitos bred in scrap tire piles and LaCross Encephalitis may be difficult to prove, follow-up studies on 69 diagnosed cases in 1981-82 showed that tires were present in 72.5% of the cases and were considered the "predominant source" of the virus 54% of the time. An average of 150 cases are confirmed annually, but a local health department in Wisconsin contends that the disease is difficult to diagnose and goes undetected up to 70% of the time. While most cases recover, there have been reported fatalities from the disease.

The U.S. Environmental Protection Agency (EPA) conservatively estimates that the current total annual health costs associated with scrap-tire related encephalitis amounts to $5.4 million. Please refer to: (The Scrap Tire Problem: A Preliminary Economic Analysis, conducted by the Environmental Law Institute in 1985 for the EPA).

While scrap tires are not known to spontaneously combust, once set on fire they are extremely difficult to extinguish. And, while tires can be burned cleanly in controlled boiler fires or energy recovery units, uncontrollable fires produce solvents and polycyclic aromatic hydrocarbons which may be carcinogenic. The lack of properly controlled oxygen to assist in combustion creates an effect called "pyrolysis", which results in an oil and sooty smoke being emitted from the fire.

Depending on the size of the pile, attempting to extinguish the fire with water may do more environmental harm than good. It may increase poor combustion and the formation of toxic by-products, or increase the mobility of such contaminants as oil run-off. Pollution of groundwater or run-off to nearby lakes and streams may occur as a result.

Additional concerns focus on the pyrolysis residue left by a tire fire. Metal concentrations and potential leachability are of special concern. Extensive studies were conducted on the residue from the Everett, Washington tire fire to identify the hazard potential. It was concluded that the residue and contaminated soil be capped with a liner and several feet of soil. Clean-up and fire fighting cost the city between $1-2 million. This represents the expense of a fire involving roughly one million tires - the Virginia fire was a magnitude of ten times greater!

Given these environmental and economic costs, it is easy to see why the public sector should consider alternatives to tire stockpiling. The EPA has conducted several studies to define the environmental and health risks of scrap tire stockpiling and dumping. The result of these studies may ultimately encourage the EPA or Congress to undertake an analysis of the potential for new or existing federal programs to address the problems. Product charges, a value added tax, subsidies, procurement requirements, public and private education, government research and development and federal regulations would be logical considerations. While it is not presently known which direction the federal government may take, many of the states are not waiting for federal action. Leaving solution of the problem to the states could result in 50 different regulatory programs, which could present real problems for those conducting interstate business.

State Regulatory Update

In 1984 Minnesota passed the first state legislation to both regulate scrap tire recovery and create a tax base from which to operate a scrap tire recovery program. The law added $4 to an existing title transfer fee for motor vehicles, which in turn is dedicated to the scrap tire program. This legislation:

(1) Prohibits the landfilling of tires effective July 1, 1985 (whole or shredded tires).

(2) Provides funds for the clean-up of large stockpiles.

(3) Establishes the authority to create a statewide scrap tire collection program.

(4) Provides for rule development to regulate collectors and processors.

(5) Creates a grant and loan program to stimulate tire recycling development.

In 1985 Washington passed the first state legislation requiring a sales tax (.012%) on the retail sale of tires. Although the amount of the tax is small, for the first time tire dealers have been given the responsibility for collecting the tax revenue to support a scrap tire disposal program. This legislation:

(1) Establishes a funding mechanism for tire pile clean-up.

(2) Emphasizes public awareness programs.

(3) Encourages local governments to work with industry to develop solutions to disposal problems.

(4) Prohibits the indiscriminate disposal of tires and directs the State Department of Ecology to establish minimum performance standards for storage and disposal of tires.

Michigan has proposed legislation very similar to Minnesota's but has attached a flat tax of $0.25 per tire sold. A total ban on the landfilling of tires is not being considered since it may leave the rural counties without an economically viable disposal option. The flat tax concept is being fought by the state's tire dealer association.

New Jersey had proposed the first "tire deposit" legislation which, if passed would have been implemented within a two year period if industry could not have demonstrated that at least 55% of the State's scrap tires were properly recovered. When returning used tires, consumers would be refunded $1.50 of the original $3 deposit charged at the time of purchase. The remainder of the initial deposit would be used to stimulate development of proper disposal programs for tires. The law would have also established the authority to write rules for regulation of scrap tire collection and disposal. Since the original legislation was proposed , changes have been made to allow the State's Deprtment of Energy and Environmental Protection the opportunity to study the scrap tire problem and make recommendations for program implementation. One recommendation could be to initiate the tire deposit program. Several other states, including California, New York, Virginia, Ohio, Wisconsin and Oregon are considering scrap tire legislation. Many are doing so because of their own historical difficulties with scrap tire disposal. Due to the mobility of scrap tire collectors, others are almost forced into tire legislation once a neighboring state has acted. Such action is taken in self defense to stem the flow of scrap tires from a more restrictive state to a less restrictive state where indiscriminate dumping has little or no preceived consequence. Although everyone can agree on the need for proper disposal programs rather than the shifting of the scrap problem from county to county and state to state, there is a variety of opinions from both government and industry on how and by whom the problem should be addressed.

Scrap Tire Recovery

Various markets exist for scrap tires including retread, tire derived fuel, asphalt rubber, rubber reclaim and crumb rubber for molded rubber applications. At most, 30% of all scrap tires are recovered for these purposes. For crumb rubber, the total market in 1984 was between 60 and 65 million pounds. This industry's existing production capacity was estimated to be between 100 and 144 million pounds per year, indicating capacity utilization of roughly 50-60% due to limited market demand. Severe capacity under-utilization was confirmed by the National Association of Recycling Industries (NARI) 1984, Census Report on recycling industries. Since this market survey was completed, market conditions for crumb and reclaim rubber have declined rather than improved.

Two current trends are reducing the number of tires that can be recycled at a profit. The first trend is the decline of the passenger retread market. This trend has already had an effect on what the tire dealer pays to get rid of his scrap since the tire jockey sees less revenue from the salvage of good casings. The second trend, directly felt by the rubber recyclers, is the decline in oil prices which makes virgin products much more competitive with their recycled rubber. Although the effects of a declining retread market has been felt for some time, the decline of oil prices is only just beginning to be felt for tire derived fuels as well as crumb and reclaim rubber. It will be several months before the full impact of a decline in oil prices, if sustained can be determined. Industry is not waiting for oil prices to stabilize, however, and is already demanding lower prices for fuel and oil based feedstocks.

Oil prices are affecting the economic recycling of scrap tires and are having a negative influence on development of recycling plants in general. Many recycling industries were born out of concern for resource conservation and waste reduction, and during the 1970's higher energy costs made recycling for product or energy recovery an economic reality. During the current energy glut (the 70's in reverse) many recycling activities may cease or look to subsidies to maintain economic viability if low oil prices continue. Communities have been making the transition for some time from paying landfill tipping fees to paying fees to resource recovery authorities for energy and/or resource recovery from municipal wastes. Such a scenario may well be the way for scrap tire disposal. As end markets pay less for processed tires, a greater reliance is being placed on the disposal fee to compensate for the difference between production costs and market values.

Energy recovery from scrap tires appears to hold the greatest promise for disposal of the large number of scrap tires not presently used by other recycling industries, at least for the short term. It is an existing fuel source that has proven environmentally sound given adequate controls. If oil prices go back up, market demands for recycled rubber and other by-products will increase and the recycling of scrap tires can shift to accommodate that market. This could result in a higher market value for crumb rubber and open up the possibility of reducing or eliminating tire disposal fees at processing plants.

Industry's Role

For all practical purposes tire scrap is presently generated by two sources - tire manufacturers and tire dealers who accept their customers' old tires. These are, therefore, the entities, in addition to tire haulers, to whom ultimate responsibility is assigned for proper disposal and any expenses attendant to that disposal.

Tire manufacturers and dealers therefore stand to gain by the establishment of sound tire recovery systems. They can help to ensure their development by:

(1) Becoming informed about which disposal alternatives are viable and what their costs are.

(2) Becoming involved, promoting and supporting economically and environmentally sound approaches that have practical applications.

(3) Ensuring that their scrap tire hauler's disposal method is above reproach. Specify delivery to sites that have been determined most desirable and investigate to ensure follow-through.

Government's Role

Solid waste matters are usually assigned to local and regional jurisdictions. Scrap tires, although difficult to handle in the operational face of a landfill, are fairly inert relative to other municipal solid waste materials. As much as the tire dealers and collectors have neglected to participate in legitimate disposal practices, local governments have neglected in many instances to provide those disposal methods whether it be landfilling or shredding then landfilling.

My investigations have led me to believe that any tire legislation or action should consider the following:

(1) A funding mechanism to clean-up the large tire stockpiles where financial liability cannot be assigned or recovered. Remember, scrap tires in large part are a consumer generated waste rather than an industrial waste.

(2) A funding mechanism should utilize an existing revenue collection mechanism so as not to create another "tax collector" or separate levels of "paper work".

(3) Statewide regulations for scrap tires to prevent a segmented and costly approach by local or regional governments.

(4) A continuation of the land disposal option until other alternatives are available or where rural areas of a state may be adequately served by the proper landfilling of the few scrap tires generated in that region. Shredding prior to landfilling would be desirable for large quantities of tires, to reduce volumes and prevent them from working their way to the surface.

(5) A tire deposit appears to be an innovative concept. In reality, such a deposit would be costly and difficult to implement due to distribution and inventory adjustment networks for tires across state borders. Additionally, tire retailers near state boundaries loose competitiveness if their neighbors across the state line do not have the same deposit or tax attached to the sale of a tire. There is a big difference in real and perceived terms between a $0.05 deposit on beverage containers and a $3.00 deposit on tires ($12 for a set of four) and how this might affect competitiveness. The only way around this would be a national deposit system... but, since tire disposal is best handled at the state/regional level, it may not make sense to collect money at the federal level.

Tire manufacturers and dealers are in a unique position to control their own destinies if they will help to provide for sound scrap tire disposal while working with state and local governments. State and local governments must make the commitment to work with industry to develop viable solutions. Such cooperative leadership can make costly and restrictive legislation unnecessary, diluting government's need for detailed involvement. And, it can provide positive publicity to erase the negative image created by broadcasts on the nightly news reporting yet another tire fire.

Shelly Sporer
Minnesota Pollution Control Agency
October 30, 1986

Minnesota's Waste Tire Management Program

Since 1983, the waste tire disposal problem has been brought to the forefront of Minnesota's solid waste management issues. Minnesota generates approximately three million tires annually. Estimates show that less than 20 percent of these tires end up at authorized landfills. The balance is discarded illegally or at unauthorized collection sites. The Minnesota Pollution Control Agency (MPCA) estimates that there are currently five million tires stockpiled at collection sites in Minnesota.

Waste tires stockpiled at collection sites pose hazards to human health and the environment. Tires offer refuge to vermin and are an ideal breeding ground for mosquitoes, one of which carries the LaCrosse Encephalitis virus. Waste tires are also a fire hazard.

In addition to the health and environmental problems caused by waste tires, many stockpile owners believe that some day their waste tires will become valuable. They also believe that they have done a service by allowing tires to be stockpiled on their property. When these people started taking in tires, there were no existing ordinances that prohibited or regulated stockpiling of tires. Many, if not all, stockpile owners charged a fee for people to dispose of tires on their land. However, in most cases, this fee is too small to allow for proper disposal at today's prices. This is assuming that money is available to clean up the stockpile which is generally not the case. Also, most stockpile owners do not react favorably when forced to clean up the stockpile.

Waste tires that are landfilled also pose problems. Whole tires when compacted in bulk and placed into a sanitary landfill spring back to their former shape and tend to work up to the surface while the fill is settling. Tires are also resistant to natural decomposition making them a permanent landfill problem. As a result, many landfill operators will not even accept tires at their landfills. The landfill operators that do accept tires prefer to stockpile the tires until they have a sufficient quantity to contract with a person to haul the tires to a collection site.

Because of the problems associated with waste tire disposal, the Governor of Minnesota appointed a Special Commission on Waste Tires in December 1983 to act as a citizen's advisory committee. The commission was to recommend to the governor ways to dispose and/or recycle scrap tires. In particular, the commission was to investigate: enacting legislation that would develop a statewide program to recycle waste tires, the creation of collection and processing sites, how a program could be funded, the utilization of waste tires as a recycled product, and the feasibility and problems of using tires as an alternate energy source.

The commission set forth three goals to be achieved when dealing with the waste tire disposal problem. The first goal was that all tires should be reused, and waste tires should be used as an alternative energy source only if better uses cannot be found and developed. The second goal was the cleanup of existing tire stockpiles in the State, and the third goal was to achieve the maximum reuse of tires in existing markets and the development of new markets.

The commission recognized that the present system of tire disposal is based on economics. The cheapest method of disposal is the one that is used. The commission also recognized that monies would need to be expended to locate and remove tire stockpiles. However, if the goal of reusing all waste tires was achieved, there would be no tire disposal problems at landfills, the stockpiling problem would be reduced from a permanent status to a temporary storage problem, and the indiscriminate dumping in wooded areas would become obsolete, thereby eliminating potential health and environmental hazards.

Based on the recommendation of the Special Commission on Waste Tires, legislation was passed during the 1984 legislative session that dealt with waste tire management. The legislation can be summarized into six main provisions. First, the MPCA was directed to conduct a waste tire study. For the study, specific areas to be reported on included: tire recycling options, waste tire collection methods, generation rates and the distribution of tires, flow control, and financial conditions and responsibility of tire collectors and processors. The study was completed in October 1985.

A second provision of the waste tire legislation was to enact a ban to prohibit the land disposal of waste tires after July 1, 1985. This ban has been interpreted to also prohibit the land disposal of tire chips and tires that are halved or quartered. We felt that if a person was allowed to halve or quarter waste tires and then land dispose of them, that would become the management practice in the future. Also, it didn't seem possible in the foreseeable future that economics alone would be sufficient financial incentive to do otherwise for the vast majority of tires.

In general, the MPCA and State policy is to minimize the dependence on land disposal of wastes. We believe the intent of the waste tire legislation is to preserve needed landfill space by removing a bulky, recyclable resource from the waste stream. Also, by preventing the landfilling of tires in any form, both the MPCA and private industry would be able to determine the raw material available for market development.

When the landfill ban took effect, there were no State permitted collection or processing facilities. Therefore, in order to minimize the impact of the ban, information on waste tire haulers, collection sites, and processors that would accept tires was collected and made available to interested parties. We worked with the local Tire Dealers Association in encouraging tire dealers not to send waste tires home with their customers, since tire dealers are in a better position to obtain the services of a waste tire hauler. Landfill owners and operators were also contacted and were told that although land disposal of waste tires is prohibited, the waste tire statute does allow for stockpiling of up to 10,000 waste tires without obtaining a waste tire permit. Therefore, it would be possible that as part of an organized collection system, landfills could be utilized as transfer stations which provide areas to accumulate waste tires prior to transport to processors.

Even though temporary stockpiling of waste tires is not a long-term solution to the waste tire problem, it does provide an interim means for addressing the immediate problem. Also, the majority of waste tires generated were not being land disposed prior to the prohibition. Rather, land disposal was utilized primarily by home owners and small quantity waste tire generators located in rural areas. Because of this, temporary stockpiling of waste tires at landfills helped ease problems caused by the ban.

A third provision of the legislation enacted a four dollar tax on the title transfer of motor vehicles in Minnesota. This tax money is divided between three different programs. One-fourth of the tax money is allocated to a program that works to beautify and enclose auto salvage yards. Two-fourths of the money is allocated to the MPCA to be used for cleaning up tire dumps under the waste tire dump abatement program. The final one-fourth of the tax money is allocated to another State agency, the Department of Energy and Economic Development. They have a grant and loan program for people who are interested in developing waste tire processing projects. The grant and loan program is the fourth provision of the legislation.

The fifth provision of the legislation directed the MPCA to establish a permitting program for waste tire collectors and processors. Draft rules have been developed for these purposes. Under the permitting program, the MPCA is required to permit tire collectors and processors with more than 500 waste tires, unless they are exempt. A permit is not required for:

1. a retail tire seller for the retail selling site if no more than 500 waste tires are kept on the business premises;

2. an owner or operator of a tire retreading business for the business site if no more than 3,000 waste tires are kept on the business premises;

3. an owner or operator of a business who, in the ordinary course of business, removes tires from motor vehicles if no more than 500 waste tires are kept on the business premises;

4. an owner or operator of a permitted landfill with fewer than 10,000 waste tires stored above ground at the permitted landfill site; or

5. a person using waste tires for agricultural purposes if the waste tires are kept on the site of use.

With these exemptions as a foundation, the permit rules outline who is required to obtain a permit, the procedures that must be followed to obtain a permit, and the information that is to be contained in the permit application. Permits are issued or denied in accordance with MPCA permitting procedures which include public participation provisions.

In addition to the permitting rules, technical rules containing facility operating standards have been developed. Compliance with the technical standards is required as part of the permit conditions. Under the rules, waste tire facilities are divided into three categories: transfer facilities, processing facilities, and storage facilities. There are general requirements that all facilities must comply with as well as requirements that are specific to each facility type.

The draft technical rules contain standards for facilities that have provisional status and standards for permitted facilities. Provisional status was developed to provide a time period during which existing facilities have an opportunity to achieve compliance with designated parts of the technical rules. Also, facilities which comply with the requirements of provisional status, are considered to be in compliance with the requirement to obtain a waste tire permit and may continue to accept waste tires once the rules become effective. Facilities that are not in compliance with the rules are required to close.

Once a facility is permitted, more stringent technical requirements become effective. The most stringent requirements are imposed on storage facilities because we believe they pose the greatest threat to human health and the environment. The technical requirements for processing facilities are not as comprehensive as the requirements for storage facilities, but they do involve planning for emergency response situations and maintaining fire control standards. Also, if the quantity of tires stored at a processing facility exceeds a specified quantity identified in the technical rules, the facility will be classified as both a processing and a storage facility. As such, the facility must operate according to both sets of facility technical requirements and must be permitted as both a processing and storage facility. Transfer facilities would have the least stringent requirements imposed upon them because of the small quantity of tires (limited to 10,000 waste tires) that would be stored there and the time interval allowed for storage.

Financial assurance is a specific provision of the technical rules. We believe that some degree of financial assurance must be demonstrated by tire collectors and processors. Specifically, they must have the financial resources available to provide for proper facility closure, which includes the removal of all waste tires and tire-derived products to authorized or approved waste tire facilities. Three mechanisms are available for tire collectors or processors to choose from to demonstrate financial assurance: letters of credit, surety bonds, and trust funds.

Since for some facilities it may be difficult to secure financial assurance for closure including all waste tires, the financial assurance requirements are divided into two phases. Phase one applies to facilities within 90 days of the effective date of the rules. Phase two applies two years after the effective date of the rules. Each phase provides different time requirements for new and old waste tires regarding the submittal of the financial assurance mechanism and the amount of the mechanism.

A distinction is made in the rules between new and old waste tires because owners or operators of facilities that have old waste tires may be eligible to receive reimbursement costs associated with cleanup of the site under the waste tire abatement rules. When owners or operators of existing facilities are determining the dollar amount of the financial assurance mechanism under phase two, the amount of financial assurance required would be the difference between the cost associated with closure of the facility and the reimbursement available to clean up the old waste tires as specified in the abatement rules. The reimbursement is only available to owners or operators of tire dumps who submitted written notification to the MPCA under the (emergency) abatement rules. The reimbursement rate will be calculated by the MPCA and will be available to owners or operators of qualifying, existing facilities within two years of the effective date of the permit rules. The actual reimbursement money will not be available until after the MPCA takes formal action against the site as specified in the abatement rules.

Under the legislation, only tire collectors and processors are required to obtain a permit from the MPCA. However, concern was expressed by interested parties that these requirements were not enough to encourage delivery of tires to acceptable facilities, and that to discourage open dumping, persons who haul tires must also obtain a permit and meet certain performance requirements. Therefore, under the general MPCA permitting authority, all persons transporting tires are now required to obtain an MPCA permit in order to operate. They must also meet certain reporting requirements. In addition to the regulations imposed on persons transporting tires, tire generators are required to only transact business with a person transporting tires who is permitted by the MPCA.

As I mentioned before, the waste tire permit rules are in draft form. As such, the content of the rules is subject to change based on comments received from interested parties during the rulemaking process. We anticipate initiating the rulemaking process for the permit rules in January 1987.

The final provision of the legislation directed the MPCA to establish a waste tire dump abatement program, including the development of emergency and permanent rules. Emergency rules governing waste tire dump abatement were adopted in October 1985 and became effective on November 21, 1985. These rules include provisions which allow owners and operators of waste tire dumps to either voluntarily sign over to the State their waste tire dump or to clean up the dump and seek reimbursement from the MPCA of up to $10.00 per ton of tires cleaned up. These provisions apply provided the MPCA has issued the owner or operator a request for abatement action. The MPCA issues such requests in accordance with the spending priorities established by statute. The emergency rules also required waste tire dump owners and operators to notify the director in writing of the dump by January 21, 1986. This notification included an estimate of the quantity of tires located at the tire dump. Eighty-five notifications for waste tire dumps were reviewed under the emergency rules and were prioritized based on the spending priorities. Expenditures of State funds depends upon the number of waste tires present at the dumps to be abated as well as the option pursued by the dump owner or operator. To date, we have initiated abatement proceedings for the two highest priority sites. The owners and operators of both these sites chose to cleanup the dump and seek reimbursement from the MPCA. Currently, cleanup plans for both these sites are being developed.

The authority for the emergency rules governing waste tire dump abatement is only effective for 360 days. Therefore, permanent rules governing abatement have been developed. These rules were adopted October 28, 1986 and contain provisions different from those of the emergency rules. The major change in the permanent rules is in the reimbursement provision. This change was made based on comments made by interested parties on the emergency abatement rules during the rulemaking process. In calculating the reimbursement rate for waste tires that do not exceed an 18 inch rim diameter, 35 inch outside diameter, and a 14 inch tire width, the following formula is used by the MPCA to determine which abatement alternative is the most cost effective.

$$R = \underbrace{[(M \times \$0.125)}_{\text{(transport cost)}} \quad \underbrace{+ \text{ or } - \ PC]}_{\text{(processing cost)}}$$

Where R is the potential reimbursement rate in dollars per ton; M is the miles needed to transport the waste tires to the processing facility; the figure $0.125 represents the cost of transporting a ton of tires one mile; and PC is the net dollar cost per ton to the responsible tire collector of processing these tires. If PC is a positive value, it shall be subtracted from the transportation cost portion of the formula. PC may not exceed $66 per ton.

Under the reimbursement rate formula, three assumptions were made. First, the tires will be transported in a vehicle capable of holding 1,000 tires. Second, it costs $1.25 per mile to operate the vehicle, and third, there are 100 tires per ton. The $0.125 per ton mile factor is calculated by multiplying $1.25 per mile by 100 tires per ton and then dividing by 1,000 tires per load. Even though these assumptions are for an optimum situation, they are also realistic based on conversations with representatives of the National Tire Dealers and Retreaders Association, wholesale tire dealers, and individuals involved in the transportation network.

The reimbursement rate for waste tires exceeding an 18 inch rim diameter, a 35 inch outside diameter, or a 14 inch tire width, will be established by the MPCA on a case-by-case basis. If the responsible tire collector seeks reimbursement for the cost of abating these tires, the responsible tire collector must submit information on the most cost effective method of transporting (if the waste tires are to be processed off-site) and processing these tires under certain time frames. The MPCA will choose a reimbursement rate that reflects the most cost effective method of transporting and processing these wastes tires.

The reimbursement option is the MPCA's approach to developing a workable cleanup program for waste tires. It enables the MPCA to work with tire dump owners to clean up existing stockpiles. When we investigated various cleanup programs throughout the United States, we found that when direct enforcement action was taken against a tire collector, the tire pile caught fire shortly after. Also, tire collectors generally do not have the money to clean up the tire dump, or the tire dump may have been created by a previous landowner. Since money is available to clean up waste tire dumps, it is cost effective if the MPCA uses the money as an incentive for the tire collector to clean up the tire dump with minimal MPCA intervention.

The reimbursement is only available for tires that were existing on site before the effective date of the rules, and to owners or operators of the site who submitted notification to the director before January 21, 1986. The emergency rules became effective November 21, 1985.

If we find out about a tire dump now, we contact the owner and inform them about the upcoming regulations. We also inform them that they are 100 percent liable for the cleanup of their dump.

The final change from the emergency abatement rules to the permanent rules was the elimination of the sign-over option. The sign-over option was intended as an option for tire collectors who want to cooperate to clean up their tire dumps, but do not have the ability to readily do so. The tire collector who owns or operates a tire dump would be allowed to sign over the tire dump to public custody. The State would provide for the cleanup of the tire dump. By allowing tire collectors to sign over the waste tires, the lengthy and expensive (staff and legal time) process of gaining possession of the waste tires could be avoided.

The reason this option was removed from the permanent rules was because it was felt that tire collectors with adequate funds available to clean up their tire dumps may try to use this option in order to escape financial liability for their tire dumps. Also, there appeared to be a great deal of confusion with this option over the recovery of expenses by the Attorney General. Many parties believed that since sign-over is a cooperative agreement, the State would not seek to recover abatement expenses. However, it was intended that the State would seek to recover actual abatement expenses, but could minimize legal and administrative expenses using the sign-over option. Considering the confusion, it was decided to delete the sign-over option from the permanent rules.

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PRESENTATION BY RICHARD KELLER, MANAGER, TRANSPORTATION AND WASTE MANAGEMENT
MARYLAND ENERGY OFFICE
SCRAP TIRE RECYCLING AND VENDOR'S WORKSHOP, NOVEMBER 13, 1986, FAYETTEVILLE, N.C.

I would like to thank the Fayetteville Technical Institute of Continuing Education, the North Carolina Association of County Commissioners and the Cumerland County Clean Community Committee for inviting me to discuss tire recycling at this conference. I will be discussing the role of government procurement in creating new markets for recycled materials.

Approximately 200 million automobile tires and 40 million truck tires are discarded each year, representing about 2 million tons of our nation's solid waste burden. The sheer numbers, however, tell only part of the story about tires. Just ask a solid waste manager or an auto and truck recycler about their biggest nightmare and one word comes to mind - tires. Even though the majority of the presentations that I make across the country are about paper or auto and truck recycling, there is rarely any presentation that I give where someone doesn't ask " What are you doing about tires? "

Why is government procurement of recycled products an important part of the solution to the tire disposal and other solid waste managment problems ? First, it is important to understand the nature of recycling. When most people think about recycling, the first thought is the collection of recyclables such as paper, metals, glass and other materials. Unfortunately, mere collection of recyclable materials does not constitute recycling. Before recycling occurs, there must be a market for the processing of the materials, and a consumer who is willing to use the product made from the recycled materials. It is only when a product made from recycled materials is used that the recycling process is complete.

Governments can play both a real and symbolic role in creating demand for finished recycled products. The real role is very obvious; government agencies can buy products made from recycled materials. In the same way that government has a role to play in managing solid wastes and collecting materials for recycling, it should also serve as a market for products made from recycled materials. The symbolic role is even more important. Government can serve as a model for other organizations through its purchasing policies. Public and private agencies can use the example set by a government agency to establish similar programs to use recycled products. This modeling policy can dramatically increase the demand for recyclable materials, thus lessening their burden on the solid waste stream.

In the area of tires, there are two major products that government can examine in order to reduce the burden of tires on our landfills and our communities. Recycled rubber from tires can be used to produce retread tires and rubber asphalt products. The purpose of my presentation is not to present a technical cost / benefit analysis on the use of these materials; instead, my purpose is to discuss the procurement process for obtaining these materials.

In understanding the procurement of recycled products, it is important to understand the PQA Theory of Recycling. PQA stands for price, quality, and availability. Virtually any recycling process can be understood by using the PQA Theory. As an example, in a community newspaper recycling program, you need a good price (P) from the newspaper market, the quality (Q) must meet the vendor and manufacturer's specifications, and the newspaper must be readily available (A). In a similar way, in examing the purchase of a recycled product, the price (P) must be competitive with the virgin product, the quality (Q) must be sufficient to perform the job required of the product, and the recycled material must be readily available (A).

In the area of price, it is important to recognize that the actual price of the product at the time of purchase may not represent the true cost of the product. As an example, if you compare one car that costs $ 5000 that gets 20 miles per gallon with a second car that gets 30 miles per gallon but costs $ 5200, the second car is the better buy over the long run because the savings in gasoline costs will far outweigh the additional $ 200 spent at the outset. As a result of this phenomenon, there is a purchasing technique called life - cycle costing, which calculates the total cost of owning a particular product.

In looking at the price of a recycled product such as retread tires or rubberized asphalt, it is important to consider the cost of the product over its entire life. In preparing their guideline for buying rubber asphalt products, the Environmental Protection Agency recognized that rubber asphalt products were more expensive initially than virgin products, but could save in the long run due to longer durability. In our view, EPA did not go far enough with their analysis. Using rubber asphalt products can save energy and also reduces the need to landfill tires. These costs (which are avoided in buying recycled asphalt) should be recognized as part of the formula for determining the true cost of buying a recycled or a virgin product.

In the area of quality, the comments on the proposed EPA guideline indicate that the jury is still out on the quality of recycled asphalt products. There needs to be more testing of rubber asphalt products and more evaluation of the performance of the products. The University of Mexico has indicated that recycled (rubber) asphalt products can be used in crack and joint sealing and seal coats applied to badly distressed pavements where complete pavement removal is the alternative and can " rejuvenate a pavement and lead to lower life - cycle costs. "
In the area of retread tires, there is a need for good data on how well retread tires perform.

In the area of availability, there is a need to increase the number of companies that produce recycled rubber products. By increasing demand for such products, governments can encourage companies to increase research and marketing to increase the use of recycled rubber. In the meantime, governments should test a variety of rubber products, and determine which products work acceptably.

In establishing a program to buy recycled products, there are six key elements that must be included :

1. Commitment - governments must make a strong commitment to using recycled materials to convince manufacturers that a real market exists. This will allow manufacturers to make the capital investment to increase the use of recyclable products such as tires.

2. Reasonable percentages - governments should set reasonable percentages for the use of recycled materials so that the specifications increase the use of recycled materials but do not limit competition.

3. Phased - in approach - don't attempt to change product usage overnight. Phase the program in and allow sufficient time to test the products and allow users to become comfortable with the products.

4. Life - cycle costing - government agencies should consider the solid waste and energy costs of a product as well as the initial cost.

5. Cooperation with purchasing officials - the solid waste and purchasing communities must work together to deal with procurement of recycled products. Solid waste officials must be aware of the purchaser's job of buying the best product at the lowest cost and provide information on recycled products to the purchasing official. Purchasing officials must be made aware of the solid waste problem and the role of government procurement in solving that problem.

6. Recordkeeping and Publicity - it is important for buyers of recycled rubber products to keep good records on what is being purchased, the recycled content, etc. and pass that information on to solid waste officials, local government officials and other interested parties so that programs to buy recycled rubber products can be improved.

Obviously, this discussion is only a brief overview of government's role in creating markets for rubber products through procurement practices. Government will need to examine other products where recycled rubber can be used and purchase the power generated through the burning of tires for energy. There is no question, however, that government will continue to play an important role in creating markets for recycled tire products.

ENVIRONMENTAL PROTECTION AGENCY

Proposed

Guideline for Federal Procurement for Asphalt Material Containing Ground Tire Rubber for Construction and Rehabilitation of Paved Surfaces

Dsk RDP 68 (86-1326)

EPA PROCUREMENT GUIDELINES

1. Implements Section 6002 of Resource Conservation Recovery Act of 1976 (RCRA).

2. Purpose and Scope :

   "... if a Federal, State, or local procuring agency uses appropriated Federal funds to purchase certain designated items, such items must be composed of the highest percentage of recovered materials practicable".

3. Guidelines :

   Fly Ash in Cement and Concrete (Implemeented).

   Paper and Paper Products.

   Asphalt-Rubber.

GENERAL REQUIREMENTS

1. Reasonable Levels of :

    A. Competition.

    B. Cost.

    C. Availability.

    D. Technical Performance.

2. Specifications Cannot Descriminate Against Recovered Materials.

3. Purchase Price Must Exceed $10,000.

4. Materials Must be "Technically Appropriate and Economically Feasible".

Dsk RDP 68 (86-1326)

"TECHNICALLY APPROPRIATE AND ECONOMICALLY FEASIBLE"

1. An ASTM or AASHTO Specification Must be Available for a Designated Application.

2. Materials Must Meet Specifications.

3. Materials Are Reasonably Available Within a Reasonable Time.

4. Materials Must be Available at a Reasonable Price.

5. A Satisfactory Level of Competition Must be Maintained.