Technical Report # 41

Asbestos Analysis of Post-Consumer Asphalt Shingles

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Results reported by:

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The Chelsea Center for Recycling and Economic Development, a part of the University of Massachusetts Lowell's Center for Environmentally Appropriate Materials, was created by the Commonwealth of Massachusetts in 1995 to create jobs, support recycling efforts, and help the economy and the environment by increasing the use of recyclables by manufacturers. The mission of the Chelsea Center is to develop an infrastructure for a sustainable materials economy in Massachusetts, where businesses will thrive that rely on locally discarded goods as their feedstock and that minimize pressure on the environment by reducing waste, pollution, dependence on virgin materials, and dependence on disposal facilities. Further information can be obtained by writing the Chelsea Center for Recycling and Economic Development, 80 Everett Avenue, Suite 221, Chelsea, MA 02150.

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1. ABSTRACT

Approximately 11 million tons of waste asphalt roofing shingles are generated and disposed of in landfills in the US per year[1]. Most of these waste shingles are deposited in landfills, creating a sizable disposal problem, and gradual loss of precious landfill space. Recycled product markets for asphalt shingles include hot mix asphalt and many States allow the use of manufacturing scrap (post-industrial) asphalt shingles in the production of hot mix asphalt for paving.

The single biggest issue that has been raised as an impediment to the recycling of waste asphalt shingles from re-roofing projects (i.e., "tear-offs", or post-consumer waste) is concern over potential asbestos content. In the past asbestos was sometimes used in the manufacturing of asphalt shingles and other shingle installation materials. It is generally acknowledged by the asphalt shingle manufacturers that between about 1963 to the mid-1970s some manufacturers did use asbestos in the fiber mat in some of their shingle products (but the total asbestos content was always less than 1%). Other materials used in shingling, such as some tarpapers and some types of asphalt cement also reportedly contained asbestos.

Asphalt Reclamation Industries (ARI) of Fitchburg, MA received a permit on June 2, 2000 from the Massachusetts Department of Environmental Protection (MA DEP) to accept post-consumer asphalt shingle waste for processing for subsequent use in making asphalt pavement. Their Asbestos Management Plan called for testing each incoming load for any suspect materials and a representative composite of outgoing loads of finished ground product.

The Chelsea Center for Recycling and Economic Development (Chelsea Center) awarded ARI a Product Testing and Development grant to test for asbestos in 417 samples collected by ARI between June and December 2000 at their facility for processing post-consumer asphalt shingles delivered by demolition contractors. The Chelsea Center also reviewed a total of 1,770 asbestos analysis reports from samples of shingle material, tarpaper and finished ground product collected between March 2000 and September 2002. The results (detailed in a table in the Report) indicated that 0.3% of the samples analyzed tested positive for asbestos at greater than 1% and an additional 0.5% of the samples contained a trace amount (less than 1%) of asbestos. However, since two thirds of the samples from which asbestos was detected were collected on only two days during this long sampling period, the actual frequency of finding asbestos in loads of shingles is probably less than indicated by this summary data.

These data and others being collected by the Construction Materials Recycling Association should allow the potential risk of exposure to asbestos during asphalt shingle processing and reuse to be more fully evaluated. Appropriate and realistic regulatory policies, processing protocols, and testing frequencies can then be agreed upon, hopefully leading to increased recycling of both manufacturing scrap (post-industrial) and post-consumer "tear-offs" asphalt shingles to uses other than landfill disposal.

2. STATEMENT OF PROBLEM AND OPPORTUNITY

Approximately 11 million tons of waste asphalt roofing shingles are generated in the US per year[1]. Approximately 10 million tons result from new roofing jobs (i.e., "tear-offs" or Post-Consumer Asphalt Shingles - PCAS) and another 1 million tons are from manufacturing scrap (i.e., post-industrial)[3,4]. These one million tons consist primarily of tab punch-outs, mis-colored and damaged shingles. Most of these waste shingles are deposited in landfills, creating a sizable disposal problem, and gradual loss of precious landfill space. About 20,000 tons of post-industrial asphalt shingles are being deposited in landfills every year in the state of Massachusetts[5] and it is estimated that Massachusetts is depositing up to 100,000 tons of PCAS annually[2].

The recycling of post-consumer asphalt shingles into hot mix asphalt (HMA) and other asphalt containing products could be desirable both economically and with regard to the characteristics of the paving material. The recycled asphalt shingles would replaces virgin asphalt in paving products at the same time as saving space in our landfills. Revenues from the sale of this aggregate substitute and from tipping fees should be sufficient to effectively process the material and, given sufficient throughput, to return enough profit to entice larger operators to join the asphalt shingle recycling industry.

Shingles are primarily composed of asphalt cement, hard rock granules, fillers, and mat fibers (cellulose or fiberglass). Since shingles contain 19 - 36 % asphalt by weight[3], the reuse of asphalt shingles can significantly reduce the usage of asphalt binder in HMA facilities. Recycling PCAS shingles in asphalt plants may also result in cost savings for disposal companies and roofing contractors. Several potential recycling markets exist around the US for asphalt shingles. In addition to HMA, this includes cold patch asphalt, dust control on rural roads, temporary roads or driveways, aggregate road base, new shingles, or even fuel. The asphalt shingle recycling industry has initially been driven primarily by the asphalt shingle manufacturers and their need to reduce the disposal costs of manufacturing (post-industrial) scrap. A laboratory study conducted by the Worcester Polytechnic Institute and University of Massachusetts at Dartmouth showed that the properties of HMA made with 3%, 5%, and 7% ground asphalt shingles did not differ significantly when compared to HMA without asphalt shingles[5]. Other studies have shown similar results and many States allow the reuse of asphalt shingles in the production of HMA. For example, North Carolina allows up to 5% post-industrial shingles in HMA[6]. The Construction Materials Recycling Association (CMRA) reports other States that allow up to 5% post-industrial asphalt shingles include FL, GA, IN, MD, MI, NJ, and PA[1]. The Massachusetts DEP also allows the recycling of post-industrial asphalt shingles when recycled into Hot Mix Asphalt[9] but the Massachusetts Highway Department has not included its use it their pavement specifications[10].

The single biggest issue that has been raised as an impediment to post-consumer asphalt shingle recycling is possible contamination asbestos that in the past was used in the manufacturing of asphalt shingles. The asphalt shingle manufacturers acknowledge that between about 1963 to the mid-1970s some manufacturers did use asbestos in the fiber mat of their shingles. Manufacturer information on precisely how many asbestos containing shingles were sold is not available, but the amount of asbestos used in shingles was typically much less than 1% of the product and it was only in a small portion of the manufacturers' production (see www.shinglerecycling.org[1]). In reality, while asbestos was commonly used in the past in some asphalt roofing materials,

asbestos was rarely used in the shingles themselves. The California Integrated Waste Management Board reports that the asbestos content in asphalt shingles was as high as 0.02% in 1963 but that this dropped to 0.00016% by 1977[3]. The EPA's (US Environmental Protection Agency) National Emission Standards for Hazardous Air Pollutants (NESHAP) regulates how asbestos containing material (ACM) is handled during building demolition or renovation and defines ACM as any material containing more than 1% asbestos as determined using polarized light microscopy (PLM).

Nationwide there are only a handful of enterprises who collect, test and grind PCAS. This diminutive market is due primarily to the following factors:

- The unknown business risks involved in processing shingles that could possibly contain asbestos,
- Lack of investment due to the potential liability of changing solid waste disposal regulations;
- The costs involved in pre-sorting shingles, testing for asbestos and developing end uses for the processed material.

With landfill tipping fees that are among the highest in the country, Massachusetts provides a unique backdrop for the recycling of asphalt shingles. This is a strong economic incentive to recycle shingles for those who will take appropriate precautions to sort and test for asbestos according to industry standards and regulations. Massachusetts is a front runner in seeking alternative and beneficial uses for solid wastes and secondary materials and has a Beneficial Use Determination (BUD) program to regulate these uses. Still, according to ARI, the above barriers serve as an impediment to reaching the recycling objectives of the MA DEP as evidenced by the Beyond 2000 Solid Waste Master Plan[7] which does not include asphalt shingles as recyclable material.

3. SCOPE OF WORK

Asphalt Reclamation Industries LLC (ARI) had plans in October 2000 were to collect, sort, test, and grind up to 30,000 tons of PCAS per year. ARI was permitted by the MA DEP to accept PCAS on June 2, 2000. The Asbestos Management Plan, stipulated in ARI's Permit #51004469 from MA DEP, calls for asbestos testing of each incoming load, any suspect materials and a composite sample from each outgoing load of finished product. If ACM (i.e., asbestos at greater than 1%) is found, it must be segregated and removed by a licensed asbestos abatement contractor. According to ARI, this testing frequency (approximately once per 3.4 tons in 2001) is greater than that performed by any other known PCAS recycler in the US (for comparison, testing is no longer required in Maine, testing is required once every 500 tons in NJ, and testing is done once every 30 tons in NC[2]).

For the testing contract with the Chelsea Center for Recycling and Economic Development (CCFRED) that led to this report, 417 samples of PCASW were to be tested for asbestos (the cost was about $12/sample). Many other samples were collected by ARI and tested as part of their permit requirements. The resulting data should help the state of Massachusetts and other States understand the extent that asbestos is present in post-consumer asphalt shingles and serve as a basis for redefining public policy regarding the entire recycling process of PCAS.

For the samples to be paid for by the Chelsea Center, ARI selected ProScience Analytical Services, Inc. (ProScience), 22 Cummings Park, Woburn, MA 01801, ELAP ID #AA000156, an accredited laboratory who prepares the sample by the ashing and staining technique and which utilizes PLM to test for asbestos according to the procedure described in EPA/ 600/R-93/116 "Test Method for the Determination of Asbestos in Building Materials", July 1993 (the NTIS publication number is PB93-18576). The results are reported in % asbestos (by visual estimation, not weight or volume percent) and are reported as 1) ND if not detected, 2) trace if less than 1%, and 3) with a numerical value if quantified to be greater than 1% asbestos. The crystalline form of the asbestos was also reported by ProScience.

4. DESCRIPTION AND APPLICATION OF RECYCLING TECHNOLOGY

4.1 Processing

The shingle grinding process and technology is adapted from the wood grinding process; whereby material is fed into a cylinder hammer mill with teeth on it. After being ground, the material drops through a screen or continues to be ground. The innovation to the grinding of shingles stems from outfitting the hammer mill with the right teeth and watering the process to contain dust but not diminish the end use of the material. Processing speeds are dependent on rotation of the mill and the placement and type of teeth.

Post consumer asphalt roofing shingles are accepted at the gate where they are weighed and the tonnage tallied. Loads are then tipped, and any incidental debris, wood and metal is segregated out and disposed of or recycled and inspected and sampled for asbestos. Acceptable material is placed in a container to await for the asbestos testing results and subsequent grinding. Any loads found to contain asbestos would be segregated, rejected and disposed of in an appropriate manner. Composite sampling and asbestos testing is done on the finished ground product as well. No post-industrial asphalt shingle processing (i.e., grinding scrap from asphalt shingle manufacturers) is done at the ARI site.

4.2 Description of Site where Technology was Applied

ARI operates a facility in Fitchburg, Massachusetts, which is strategically situated in or near urban areas close to sources of raw material and consumers of processed material. ARI actively sources material from a number of waste haulers and roofing contractors located in Central and Eastern Massachusetts.

ARI's Fitchburg site is situated in north central Massachusetts on the Fitchburg/ Leominster line less than one mile from Massachusetts Route 2. Formerly a transfer station and recycling center, the site is comprised of four acres of land, a 15,000 square foot office building, a 21,000 square foot storage building, a 100,000 ton truck scale and 1 acre of paved asphalt ideally suited for this type of operation. The site, which is a permitted recycling center by the MA DEP as well as the Town of Fitchburg, is leased under a long-term lease from AKS from Leominster, MA.

The site is permitted to accept 375 tons per day and to stockpile up to 2500 tons of shingles indoors. Shingles are ground at a rate of approximately 40-60 tons per hour and according to a size specified by the customer (generally 3/8" to ½"). A hammer mill dry grinder is used. The grinder is especially equipped with dust abatement systems and magnets for separating out nails and other metal. Ground material is stockpiled under cover to await transportation to customers' sites (PJ Keating was the sole end user to date and uses the material for road base and hot mix asphalt for paving).

5. TESTING RESULTS

5.1 Testing Results

According to ARI, they collected and analyzed more than 3,000 samples of asphalt shingles, finished ground product and tarpaper and had them analyzed according to USEPA method 600/R-93/116. This data is the single largest source of asbestos test data from post-consumer asphalt shingles and related materials in the United States[2].

Of these samples, 417 were collected and analyzed by ProScience between June 20, 2000 and December 12, 2000. The analytical cost of these samples were reimbursed by the Chelsea Center and laboratory results from these analyses and the laboratory's certification are in the Chelsea Center's files.

The Chelsea Center was also allowed to review additional sampling and analysis results that ARI had submitted to the MA DEP according to their permit. All samples were analyzed by EPA method 600/R-93/116 but, in addition to the ProScience laboratory, some samples were analyzed by Scilab Boston Inc. (Weymouth, MA) and URS Corporation (Salem, NH). Table 1 summarizes the results from the 1770 analytical reports reviewed by the Chelsea Center (including the 417 referred to above). They were collected between March 21, 2000 and September 25, 2002.

Table 1: Summary of Results of Analytical Reports reviewed by Chelsea Center

material analyzed	Number of samples with the following results					# samples w/ > 1% asbestos	% samples w/> 1% asbestos
	no asbestos detected	trace asbestos detected	2% asbestos	5% asbestos	TOTAL SAMPLES		
shingles	1623	8	3	2**	1636	5	0.3%
tarpaper	109	0	0	0	109	0	0 %
ground product	23	1	0	1[#]	25	1	4 %
TOTAL	1756	9	3	3	**1770**	6	0.3%
% of total	99.2%	0.5%	0.17%	0.17%	100%		

ARI reported that the two shingle samples** that were found to contain 5% asbestos (on 8/29/00) were re-analyzed and found not to contain asbestos, the initial result being attributed to human error.

Composite samples from finished ground product are analyzed before being processed into HMA. After the May 22, 2001 sample[#] was found to contain 5% asbestos, three additional samples were taken and analyzed for asbestos and they were found to contain none. So apparently only a small portion of the finished product pile contained greater than 1% asbestos.

Among the additional sample results not reviewed by the Chelsea Center, ARI also reported that in May 2001, a sample[$] of tarpaper tested positive for asbestos at 5%. It was re-tested, confirmed to be an ACM (asbestos containing material) and the batch of shingle material that contained that tarpaper was properly abated by a company in Worcester, MA.

Based on this additional information provided by ARI (by email), revised statistical results are shown in Table 2.

Table 2: Revised Summary of Results based in Additional Data from ARI

material analyzed	Number of samples with the following results					# samples w/ > 1% asbestos	% samples w/> 1% asbestos
	no asbestos detected	trace asbestos detected	2% asbestos	5% asbestos	TOTAL SAMPLES		
shingles	1625	8	3	0	1636	3	0.2%
tarpaper	109	0	0	1[$]	110	1	1 %
ground product	23	1	0	1[#]	25	1	4 %
TOTAL	1757	9	3	2	**1771**	5	0.3%
% of total	99.2%	0.5%	0.17%	0.11%	100%		

Overall, 0.3% of the samples analyzed tested positive for asbestos at greater than 1% and an additional 0.5% of the samples contained a trace amount (less than 1%) of asbestos. However, it is important to note that of the 14 samples found to contain asbestos (trace or greater than 1%), eight were collected during on May 22, 2001 and two were collected on June 20, 2000. Of the remaining four samples collected on all the other days during the two and a half year period, three results showed only trace amounts and the fourth was the tarpaper sample whose load was abated. Therefore, the actual frequency of finding asbestos in loads of shingles is probably less than that indicated by this summary data.

In addition to the samples taken at ARI's Fitchburg, MA facility, ARI reported that the same analytical laboratory (ProScience) analyzed 444 composite samples from 4,000 tons of post-consumer shingle waste processed in 1999 in New Hampshire. They reported that the results did not indicate any asbestos containing material greater than the 1 % reporting limit[2].

Similar findings of only very infrequent asbestos detection have been reported elsewhere. A study by Central C&D Recycling in Des Moines, Iowa analyzed over 3000 demolition samples (including post-consumer shingles) found no ACM (i.e., no samples contained more than 1% asbestos)[2]. In Maine the testing of 118 loads of post-consumer asphalt shingles from demolition activities found no evidence of ACM[1].

5.2 Impact of Asbestos Testing on PCASW Processing

According to ARI[2]: *only 4,500 tons of PCAS has been processed at the ARI facility up until December 2001. The frequency and cost of sampling and analysis has placed an enormous financial burden on them. The economic gain to assume the risks and liabilities both known and unknown is sharply diminished by the cost of sampling and analysis for asbestos. At some point, the data should suggest that the small statistical likelihood for asbestos in PCAS is not worthy of the frequency of testing now underway in Massachusetts. Beyond the financial impact of testing are the processing and storage challenges surrounding the testing events and time delays in getting results prior to the material being transported (5-day laboratory turn-around for standard pricing). ARI believes that 1 sample per 30 tons is sufficient to minimize the risk of asbestos being in the final product destined for recycling.*

5.3 Applicability to the Recycling Industry

ARI's goal is to divert 20,000 – 50,000 tons per year of roofing shingle tear-offs (PCAS) from the waste stream and convert them into useful, cost effective and environmentally sound raw materials for asphalt pavers and roofing manufacturers.

5.4 Current Situation

In 2002, ARI was continuing to gather data on the asbestos content of shingle material as well as fine-tune the process of sorting and grinding whenever PCAS was processed. A permit modification request (#21004193) had been submitted to MA DEP but was not available for review for this report. In early 2003, ARI reported that they has ceased shingle grinding operations at their Fitchburg facility and were looking for a new location in the area.

6. ECONOMIC INFORMATION

The recycling of PCAS should be cost effective where landfill-tipping fees for C&D (construction and demolition) waste are in excess of $50 per ton[2]. The grinding, sorting, testing (~$12/sample for PLM analysis), housing, regulatory and administrative costs exceed $39 per ton[2]. Profitability is largely dependent upon volume, cleanliness of the incoming loads and testing frequency. Landfill pricing has steadily increased providing an impetus for roofers to find less costly disposal alternatives.

7. REGULATORY/SAFETY ISSUES AND REQUIREMENTS

In Massachusetts, a BUD "permit" must be obtained from the MADEP to process secondary materials (such as used asphalt shingles) into new products such as paving asphalt. ARI was the first and only company to request and receive a permit of this kind for this PCAS material[2]. The BUD for ARI was based on the sorting, testing and processing being done indoors and daily tonnage cannot exceed 365 tons. Samples from all suspect materials from incoming loads and a composite sample from the finished product is required to be collected and analyzed.

Processing aggregate (such as sand and gravel) is typically an outdoor activity. ARI reports that operating this aggregate processing facility indoors is a challenge[2] but one that places the necessary controls on dust, noise and other pollution and which should relieve concerns for environmental and health impacts.

8. TRANSFERABILITY OF THE RESEARCH

ARI estimates that there is a total source of approximately 100 – 150,000 tons of asphalt shingles generated in Massachusetts per year (perhaps 25,000 – 30,000 tons are post-industrial waste). The basis for this estimate is as follows:

Approximately 10-15% of C&D waste is estimated to be waste asphalt shingles (according to a Clean Washington Center C&D Market Assessment report[2]). Assuming that 10% of the 4.3 million annual tons of Massachusetts C&D waste is shingles, this would equate to 430,000 tons. Assuming that approximately 50% of that amount (200,000 tons) is readily separable from the C&D waste stream[2], ARI's goal to collect and process 30,000 tons per year would recycle about 15% of the Massachusetts supply of asphalt shingles presently being disposed.

Because of the large amount of HMA used every year (8 million tons in Massachusetts[5]), the entire 200,000 tons of Massachusetts post-consumer asphalt shingles could be utilized by incorporating them even at a low rate of 2.5% (weight of recycled shingles to total weight HMA, usually a rate of 5% is used, see Section 2.0, fourth paragraph).

Another Massachusetts company, Aggregate Industries Inc., has reportedly been considering grinding post-industrial asphalt shingles[2]. Although processing post-industrial asphalt shingles does not carry a possibility of asbestos contamination and is a proven economic effort[2], the amount available in Massachusetts does not completely satisfy the opportunity to replace virgin asphalt with reclaimed asphalt from asphalt shingles. Therefore, while Aggregate Industries still has a concern for the associated product liability of asbestos in the end use of the ground product, they reportedly have filed for a BUD permit with the MA DEP to collect and process PCAS and a final decision is pending[2].

9. RECOMMENDATIONS FOR FUTURE WORK

The required testing frequency for asbestos in an asphalt shingle waste stream undergoing recycling varies from State to State as does the precedence for legal action taken against asbestos handlers. To date, some have felt that there has been insufficient data available in Massachusetts and the nation to assess the necessity for more or less asbestos testing. There is a national need for the collection of data to conduct a comprehensive asbestos study and to develop accepted protocol to minimize the liability and potential health threat, which will also extend to Massachusetts.

The Construction Materials Recycling Association (CMRA[8]) has begun a nationwide drive sponsored by the USEPA for asbestos in shingle data and ARI is participating in this study by providing them with the all the data reported herein. Their website (www.shinglerecycling.org) summarizes these data and presents other information regarding the recycling of asphalt shingles.

ARI will continue to work with the Chelsea Center, MA DEP and USEPA to help determine the risks of recycling PCAS and to establish a workable policy on the associated collection, handling, testing and recycling of post-consumer asphalt shingles.

10. CONCLUSIONS

The Chelsea Center funded the asbestos analysis of post-consumer asphalt shingles to assist in the gathering of data that would lead to environmentally and economically sound policies relating to the recycling of this material.

This data and other asbestos testing data undertaken by ARI, and other testing performed around the country have shown little to no presence of asbestos in post-consumer asphalt shingles and related materials collected from the demolition material from asphalt shingle re-roofing projects. Based on the fact that only small amounts of asbestos were ever used in the manufacturing of asphalt shingles, this finding is not surprising.

This information should allow the potential risk of exposure to asbestos during asphalt shingle processing to be evaluated so that regulatory policies, processing protocols, and testing frequencies can be agreed upon. This should then lead to increased recycling of waste (both post-industrial manufacturing scrap and post-consumer "tear-offs") asphalt shingles to other beneficial uses.

11. REFERENCES

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