Evaluation of the Infratest Asphalt Analyzer for Performing Extractions on Recycled Asphalt Materials

Final Report for MLR-17-01

March 2017

Highway Division
Evaluation of the Infratest Asphalt Analyzer for Performing Extractions on Recycled Asphalt Materials

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By Kevin B. Jones, PE
Materials Testing Engineer
515-239-1237

and

Jon Arjes
Lead Bituminous Technician
515-239-1226

and

Michelle Barger, Ph. D
Chemist

Office of Construction and Materials
Highway Division
Iowa Department of Transportation
Ames, Iowa 50010

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5. AUTHOR(S)  
Kevin B. Jones, PE
Materials Testing Engineer

Jon Arjes
Lead Bituminous Technician

Michelle Barger, Ph. D
Chemist

6. PERFORMING ORGANIZATION ADDRESS  
Iowa Department of Transportation
Office of Construction and Materials
800 Lincoln Way
Ames, Iowa 50010

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DISCLAIMER

The contents of this report reflect the views of the authors and do not necessarily reflect the official views or policy of the Iowa Department of Transportation. This report does not constitute a standard, specification or regulation.
INTRODUCTION

InfraTest, a company in Germany, makes an automated asphalt extraction device that follows the requirements of ASTM D2172. The company offered the Iowa DOT an opportunity to borrow the equipment for a one month trial. The equipment has the potential to be much quicker, less labor intensive, and much safer than the Iowa DOT’s current procedure.
On Iowa HMA projects the extractions are done primarily for two purposes:
1. The value of the binder in the recycled asphalt pavement (RAP) is paid to the contractor at the price bid for virgin binder.
2. The extracted aggregates are evaluated for specific gravity, absorption, and aggregate angularity.
It is important to ensure that any new method of extraction not have a bias from what the current procedure, ASTM D2172/ AASHTO T164, Method A with normal-propyl bromide, provides for asphalt binder content.

OBJECTIVES

The three main objects were:
1. Perform a hazard assessment on the Asphalt Analyzer. Compare the risks and potential hazards of both procedures.
2. Compare the asphalt binder results of the Asphalt Analyzer to the current modified AASHTO T164, method procedure on a range of Iowa RAPs.
3. Determine the amount of staff time needed to complete an Asphalt Analyzer test vs the staff time needed for the current procedure.

WORK PLAN

Eight RAP samples with binder contents from 3.4 percent to 6.0 percent were selected from samples submitted for Iowa projects in 2016. They were split to do comparative and repeatability testing. Five splits of each of the eight RAP samples were run in the Asphalt Analyzer with Trichloroethylene (TCE) as the solvent. One split was tested according to the current modified AASHTO T164 with N-Propyl Bromide (NPB) as the solvent.

One unanticipated issue came up with the Asphalt Analyzer. The number of wash cycles to achieve “not darker than a light straw color” was beyond the capability of the TCE reservoir and the recycler to keep up after about 9 to 10 wash cycles. The unit would shut down and not restart until sufficient TCE had been recovered. This may have been a matter of adjusting the heaters and/or the temperature of the cooling water. Twelve to 13 cycles total were needed on most of the RAP samples.

Operation Procedures and Hazard Assessment
Both TCE and NPB pose a health risk to testing personnel if not used correctly. The current standard operating procedure in the laboratory when working NPB is to have two technicians in the area in case of an overexposure accident. Michelle Barger, trained in performing hazard
assessments, observed both procedures and documented the associated risks. The results are in Appendix A and summarized below:

When observing the two methods, the by-hand method was found to present more opportunities for exposure. Engineering controls are applied to minimize the risk, but when compared to the machine, they are not as effective. The machine is able to extract the asphalt while enclosing the processes. The Analyzer reduces the time and volume of solution needed with running the test, providing further controls to reduce risk. A Risk Assessment returned similar findings. The by hand method was identified as a test with moderate risk, whereas the Asphalt Analyzer scored in the low risk range. It is concluded that the machine can provide superior risk controls, leading to improved health and safety conditions.

InfraTest has an optional closed system for adding TCE that was not shipped with the unit. This engineering control would further reduce exposure and potential risk further.

**Data Analysis**
Figure 1 shows the comparative results of the two methods. The detailed data is in Appendix B. The standard error is 0.068%. There is a small bias with the asphalt analyzer producing slightly higher asphalt binder contents than the T164 method.

The repeatability of the asphalt analyzer was determined using ASTM E691. The repeatability standard deviation is 0.080%. The precision and bias statement for T164 has a repeatability (single-laboratory) standard deviation of 0.18%.
Cost Analysis

Two advantages to the Asphalt Analyzer were the reduced technician time needed to complete the extraction and the reduced time from the start of the test to obtaining the final test results. The T164 test took from 2.5 to 3 hours per extraction where the technician was constantly adding solvent or transferring solvent to the second centrifuge to filter the fines. Afterwards the aggregate washed over the #200 sieve and then dried. The Asphalt Analyzer process saved over all about 1.5 hours of staff time per extraction. There was additional time needed to check the stability of the solvent and running the unit cleaning cycles periodically. With the Asphalt Analyzer, the unit was loaded and left to do the cleaning and filtering while the technician was free to perform other tasks. The unit dried the sample and at that point the sample was ready for gradation, absorption, and specific gravity testing.

The Asphalt Analyzer procedure allowed for quicker turnaround for test results. Where the modified T164 procedure required a 16-hour presoak of the RAP in solvent and a wash and drying after the extraction, the Asphalt Analyzer required neither. A sample could come in one day and binder and aggregate results could be completed by the next morning.
The costs associated with each method are based on 125 tests per year:

**T164**
Solvent usage of about 220 gallons per year (including disposal)  $ 8000/year  
Test Equipment, Centrifuges $8000 @ 10 year life 800/year  
Staff-hours 50% @ $16/hr, 50% @ $27/hr, 2.5 hr/test 6720/year  

Total  $15520/year

**InfraTest Asphalt Analyzer**
Solvent usage of about 15 gallons per year (including disposal)  $ 400/year  
Stabilizer, 1L 350/year  
Test Kit Refills 250/year  
Test Equipment, Asphalt Analyzer $70,000 @ 10 year life 7000/year  
Staff-hours 50% @ $16/hr, 50% @ $27/hr, 0.5 hr/test 1345/year  

Total  $ 9345/year

The price for the unit and a water chiller is about $70,000. The payback period based on the labor and solvent cost savings ($12,375/year) would be about 5.5 years.

**CONCLUSIONS AND RECOMMENDATIONS**

Based on the results of this study, the following conclusions can be stated:
1. The Asphalt Analyzer can significantly reduce the solvent exposure risk to the technician performing the test as compared to modified AASHTO T164, Method A.
2. The single laboratory repeatability of the Asphalt Analyzer is about half that reported in the modified AASHTO T164 test procedure.
3. The Asphalt Analyzer resulted in a slightly higher asphalt binder content that the T164, method A test. For the application intended in Iowa, the small bias is well within an acceptable range.
4. The Asphalt analyzer can be operated at a lower cost because of a significant reduction in labor and solvent waste.
5. The turnaround time on sample binder and aggregate results can be one day with the Asphalt Analyzer. The current Iowa DOT procedure takes two to three days.

Based on the results of this study, the recommendation is for the Iowa DOT to purchase a completely enclosed automated asphalt extraction unit from InfraTest with the stipulation that, “The unit needs to be capable of producing a minimum of 13 continuous washing cycles without operator intervention with up to a 2.5 Kg normal RAP sample.”

It should be noted that trichloroethylene is currently being reviewed by the EPA with one possible outcome being some type of ban that could affect the availability and uses.
ACKNOWLEDGEMENT

The authors wish to extend appreciation
APPENDIX A
Hazard Assessment
Hazard Assessment of *Infratest* Asphalt Analyzer and AASHTO method T 164, Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt

Introduction

The Bituminous section of the Materials Lab employs AASHTO method T 164[1] to extract and calculate the binder content of asphalt samples. When performing the Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA) a powerful solvent is employed to dissolve away the binder. Solvents that have been used for this purpose are Trichloroethylene (TCE) and N-Propyl Bromide (NPB). Both solvents present health hazards to the eyes, skin, respiratory system, digestive system, and central nervous system, the SDS for each chemical is included in Appendix A. TCE is also recognized as a suspected human carcinogen. Due to the inherent hazard of the solvents, an alternative to AASHTO method T 164 was investigated to determine if exposure to binder could be decreased by using a machine that has automated the method, an instrument referred to as an Asphalt Analyzer. The Asphalt Analyzer is new to the field of extraction and the Laboratory would like to compare the two methods to determine if the Asphalt Analyzer can reduce the risk of solvent exposure for the technician. To examine the potential benefits of the automated system both methods were observed and compared. Special attention was taken to identify points of exposure to the solvent during the two extraction processes. A Risk Assessment was applied to each procedure as a secondary comparison.

When conducting hazard and risk assessments it is important to first clarify the two terms. A hazard is simply a condition or set of circumstances that present a potential for harm. Hazards are divided into two broad categories. (1) Health hazards that cause occupational illnesses and (2) Safety Hazards that cause physical harm or injuries.[2] Risk is the chance or probability that a person will be harmed or experience an adverse health effect if exposed to a hazard.[2] For the solvents used in this study, TCE and NPB, each have an inherent hazard of harming health mainly through contact with skin and inhalation. The potential for risk is more difficult to ascertain. By carefully reviewing the tests and comparing points of possible risk the safer method can be identified.

**AASHTO Method T 164**

To briefly summarize AASHTO Method T 164 the steps are reviewed below. To reduce exposure to the volatile solution nearly all work is performed in a standing hood, referred to as the working hood, figure 1A. Waste disposal and cleaning is performed in an adjacent hood referred to as the waste hood.

1. A sample of HMA is weighed and recorded. The sample is then soaked in a solvent, NPB. The solvent reacts with the binder and dissolves it into the liquid phase, allowing for separation of the solid-phase aggregate.
2. Following the NPB exposure, the sample is transferred to a centrifuge bowl, see figure 1B. The bowl is screwed in place and rinsed several times with NPB until the extract from the centrifuge is not darker than a light straw color. When rinsing, the
effluent from this process is collected in a large Erlenmeyer flask (figure 2). The bowl contains the coarse fraction of the aggregate. Fine particles are carried away and included in the extraction portion that was collected in the Erlenmeyer flask.

3. To capture the fine particles included in the extract, a second centrifugation is performed using a high speed centrifuge capable of capturing the fine fraction (figure 2A and B).

4. Effluent or waste from the fine collection is centrifuge off and captured in a separate vessel. The waste from the method is removed from the working hood to a second hood where used NPB is stored (figure 3A).

5. Parts are cleaned by transfer to the waste hood. They are thoroughly rinsed and placed back in the working hood (figure 3B, and 3C).

6. The centrifuge bowl with the coarse fraction and centrifuge tube containing the fines are placed in an oven to drive off any remaining NPB, leaving only aggregate.

7. The percent binder is calculated by adding the two aggregate fractions together, all mass lost is assumed to be asphalt binder.

Automated Asphalt Analyzer Method

The Asphalt Analyzer is an alternative to the by hand method described above. The Analyzer is a machine that can perform extraction with little human interaction. The Analyzer is shown in figure 4. The steps used when analyzing HMA are similar to the by-hand method, a sample is exposed to solvent, the asphalt is dissolved away and the coarse and fine aggregate fractions are isolated. The steps are summarized below.

1. A wash cycle begins by filling a screened drum with HMA and recording the mass, figure 5A. The drum is then inserted into the washing chamber of the Analyzer, figure 5B.

2. While in the chamber the sample will be saturated with the solvent, TCE, and agitated. The binder will be dissolved away, while coarse grains will be retained by the drum screen. Fines will escape through the screen and transported to a high speed centrifuge where they are captured on the centrifuge tube, figure 5C.

3. At the conclusion of the wash cycles, the drum and the centrifuge tube are removed. The percent binder of the sample is calculated by the mass differences of the washing drum and the centrifuge tube.

4. Because the solvent will eventually destabilized when exposed to the binder the machine requires monitoring of the solvent during use. Periodically, a colorimetric test is performed in a standing hood to confirm the TCE is stable, figure 6A. If needed a stabilizer or additional TCE is added via the solvent storage compartment, figure 6B.

5. Effluent generated from the washing is recycled by distillation, performed within the Automatic Analyzer. Removal of the waste portion that cannot be distilled is performed by opening a spout below the TCE storage area, figure 7A. The waste is gathered in a beaker and poured off into a waste bucket in a hood, figure 7B.

6. Cleaning is performed by running a wash cycle without a sample present, this allows all parts to remain the closed system.
Comparison of Methods

When comparing the two methods it was determined the by-hand method has a greater opportunity for solvent exposure. When performing the by-hand method the test takes approximately three to four hours and the technician uses between 6 and 8 liters of solvent. This volume is considered a high use of volatile liquid for a bench top test. The liquid is poured during several steps, and at times, liberally squirted onto equipment for cleaning. By pouring and splashing the solvent, the volatile liquid can overwhelm the hood and escape. During clean up parts are removed from the working hood to the waste hood. These pieces have residual effluent and solvent on them, when carried out of the hood they introduce volatiles into the lab atmosphere and any technicians working nearby. The following points present an occasion for solvent exposure via inhalation:

- Pouring the sample into the centrifuge bowl.
- Rinsing the sample by adding more solvent to the bowl.
- Collecting the effluent in the Erlenmeyer flask.
- Pouring the effluent into the high speed centrifuge.
- Cleaning the centrifuges and removing parts from one hood to another.
- Generally many steps introduce the solvent to the open hood atmosphere and create a high surface area of solvent interaction with the hood atmosphere.

In contrast, the Asphalt Analyzer provides engineering controls that greatly reduce the time and potential for exposure. The extraction process is performed within the closed unit, which greatly reduces the potential for exposure. The machine is designed to contain the volatile liquid within the closed unit, and secondary confinement measures can be applied by placing the machine in a hood. The potential points of exposure observed for the Analyzer were identified as:

- Adding the solution to the machine
- checking solvent stability
- removal of unrecyclable waste

Each of these tasks involve a comparatively small volume of solvent (50-100 ml). The time of exposure to this small volume when performing the tasks is greatly reduced, taking 15 to 30 minutes maximum. By using a small amount of solvent for a short period of time the possibility of exposure is further suppressed during these steps of the test.

Risk Assessment

A Risk Assessment Tool was used for both methods and is presented below in Appendix B. The assessment compares the same parameters for each method. A rubric is presented where each task that can affect risk is rated. Each task is assigned a value between zero and five. Zero is not applicable and 5 being extreme. All factors are added together to arrive at the risk score. A low score, will yield a value below 15 signifying a low risk tests, a moderate risk 15-25, high 26-30 and extreme above 30.
The by hand method received a risk score of 15, classifying the tests as one with moderate risk. The Asphalt Analyzer method received a low risk scored, with a value of 10. The major influence on the difference in risk level was found to be the large volume of solvent used in the by-hand method. The comparatively low volume needed when testing with the Asphalt Analyzer greatly reduced the risk score.

Summary

A by hand method and a machine based method for extracting the bitumen from HMA were compared to determine which can provide the least risk for solvent exposure. The current method used in the laboratory utilizes standing hoods. A requires the technician to consume a large volume of solvent, the hood is intended to suppress or prevent exposure to the chemicals applied. The second method involving the Asphalt Analyzer performs the extraction in a closed automated system. The closed unit prevents volatile solvents for escaping and greatly reduces the time and volume of solvent applied by the technician. Points of possible exposure were identified for both test methods and a second evaluation, an Assessment Tool, was applied to provide a secondary means of comparison.

When observing the two methods the by-hand method was found to present more opportunities for exposure. Engineering controls are applied to minimize the risk, but when compared to the machine, they are not as effective. The machine is able to extract the asphalt while enclosing the processes. The Analyzer reduces the time and volume of solution needed with running the test, proving further controls to reduce risk.

A Risk Assessment returned similar findings. The by hand method was identified as a test with moderate risk, whereas the Asphalt Analyzer scored in the low risk range. It is concluded that the machine can provide superior risk controls, leading to improved health and safety conditions.
Figure 1. (A) Working hood where HMA is dissolved and aggregate fractions are centrifuged and dried. (B) Centrifuge bowl for large aggregate fraction. Erlenmeyer flasks catches the extract containing fine aggregate.

Figure 2. (A) The fine-extract collected in the Erlenmeyer flask is centrifuged. (B) The centrifuge tube retains fine aggregate particles.
Figure 3. (A) Waste from the fine fraction is poured off into the waste barrel. (B) Parts are rinsed with NPB until clean. (C) A cleaned part is transferred out of the hood.

Figure 4. Asphalt Analyzer, a self-contained machine that can automate asphalt extraction.
Figure 5. (A) The HMA sample is placed in a washing drum and weighed. (B) Washing drum is inserted into the Asphalt Analyzer. (C) High speed centrifuge tube showing fines collected.

Figure 6. (A) One milliliter of solvent is tested for stability. (B) Needed solvent is added by opening the storage hood and pouring from beaker.
Figure 7. (A) Waste is removed by opening the spout and collected in beaker. (B) Beaker is poured out into waste bucket contained inside hood.

References:
MATERIAL SAFETY DATA SHEET

SECTION 1 — PRODUCT IDENTIFICATION

Product identifier: VDS-3000 — Stabilized N-Propyl Bromide
Product Number: 1610, 1611, 1614
Product use: Cleaner-Degreaser, Printed Circuit Boards cleaning, Precision cleaning, Metal cleaning, Carbon removal, Automotive parts cleaning, Drying agent.
Manufacturer's name and address: Refer to supplier
Supplier name and address:

ALBATROSS USA INC./EXPERT WORLDWIDE
3641 36th Street 5439 San Fernando Road West
Long Island City, New York Los Angeles, California
United States United States
11106 90039
718-392-6272 818-543-5850
Emergency Telephone #: Chemtrec (Day or Night) 800-424-9300
(For Chemical Emergency: Spill, Leak, Fire, Exposure or Accident)

This MSDS complies with 29CFR 1910.1200 (Hazard Communication Standard) and WHMIS regulations.
IMPORTANT: Read this MSDS before handling and disposing of this product. Pass this information on to employees, customers, and users of this product.

SECTION 2 — CHEMICAL COMPOSITION/HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>CAS #</th>
<th>(weight)</th>
<th>Exposure Limit (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n-Propyl bromide</td>
<td>106-94-5</td>
<td>&gt; 94</td>
<td>*</td>
</tr>
<tr>
<td>t-Butanol</td>
<td>75-65-0</td>
<td>&lt; 2</td>
<td>100 ppm</td>
</tr>
<tr>
<td>1,2-Epoxybutane</td>
<td>106-88-7</td>
<td>&lt; 2</td>
<td>400 ppm</td>
</tr>
<tr>
<td>Acetonitrile</td>
<td>75-05-8</td>
<td>&lt; 2</td>
<td>40 ppm</td>
</tr>
</tbody>
</table>

Not established by OSHA. Independent sources recommend a TLV of 100 ppm. The E.P.A. recommends that use of a pH adheres to an acceptable exposure limit of 25 ppm over an eight-hour time weighted average.

Chemical Family: Alkyl Bromide  CAS No.: Mixture

SECTION 3 — HAZARDS IDENTIFICATION

***POTENTIAL HEALTH EFFECTS***

Target organs: Eyes, skin, respiratory system, digestive system, central nervous system

Signs and symptoms of short-term (acute) exposure:

Inhalation: Breathing vapours or mists may be harmful. Inhalation may cause irritation to the nose, throat, and respiratory system. Symptoms of overexposure may include headache, nausea, vomiting, dizziness, loss of co-ordination, coughing, and shortness of breath (CNS depression). In confined or poorly ventilated areas where the vapour concentration is very high, vapours can rapidly accumulate and cause unconsciousness and death.

Skin contact: Skin contact may cause mild irritation. Symptoms may include slight swelling and redness. Direct skin contact may result in absorption, but absorption does not occur quickly and symptoms of toxicity are not anticipated under normal conditions of use.
**SECTION 4 — FIRST AID MEASURES**

**Inhalation:** Immediately remove person to fresh air. If breathing stops, provide rescue breathing. If breathing is difficult, oxygen should be administered by qualified personnel. Obtain medical attention immediately.

**Skin contact:** Wash skin with mild soap and running water, while removing contaminated clothing. If irritation persists, obtain medical attention. Launder clothing before re-use.

**Eye contact:** For exposure to vapours, remove person to fresh air. If irritation or redness develops, flush eyes with water and obtain medical attention. For direct eye contact, flush eyes with running water for at least 15 minutes. Obtain medical attention.

**Ingestion:** If swallowed, DO NOT induce vomiting. Obtain medical attention immediately. This material is a potential aspiration hazard. If person is drowsy or unconscious, place on left side with head down. Never give anything by mouth to an unconscious person.

**SECTION 5 — FIRE FIGHTING MEASURES**

**Flash point (Method):** None

**Flammable/Explosion limits (% by volume in air):** 4.0 – 8.0

**Auto ignition temperature:** 490°C for n-propyl bromide

**Extinguishing Media:** Carbon dioxide, dry chemical powder, alcohol foam or polymer foam (class ABC, BC fire extinguisher). Water may not be effective.

**Special Fire Fighting Procedures:** Wear self contained breathing apparatus and protective gear to prevent eye and skin contact.

**SECTION 6 — ACCIDENTAL RELEASE MEASURES**

**Personal precautions:** Restrict access to area until completion of clean-up. Ensure clean-up is conducted by trained personnel only. All persons dealing with clean-up should wear the appropriate protective equipment including self-contained breathing apparatus. Keep all other personnel upwind and away from the spill/release.

**Environmental precautions:** Ensure spilled product does not enter drains, sewers, waterways, or confined spaces. Dike far ahead of the spill for later recovery or disposal.

**Spill response/Cleanup:** Eliminate all sources of ignition and remove any hot metal surfaces. Ventilate area of release. Stop leak if you can do so without risk. Use water spray to reduce vapours. Contain and absorb with non-combustible absorbent material, then place absorbent material into a container for later disposal (see Section 13). Contaminated absorbent material may pose the same hazards as the spilled product. Notify the appropriate authorities as required.

**Prohibited materials:** None known.

**Special spill response procedures:** If a spill/release in excess of EPA reportable quantity is made into the environment, immediately notify the national response center (phone: 1-800-424-8002).
DOT/CERCLA Reportable quantity: 1,2-Epoxybutane (RQ 100 lbs.)

SECTION 7 — HANDLING AND STORAGE

Safe handling procedures: Use in a well ventilated area. Avoid inhalation of vapours. Avoid contact with skin, eyes, and clothing. Wash thoroughly after handling. This material can be ignited by ignition sources, heat, sparks, and flame. Eliminate all ignition sources. Bond and ground containers, hoses and piping when transferring liquid. Use caution when opening cap. Keep container tightly closed when not in use.

Storage requirements: Store in a cool, dry, well-ventilated area away from all sources of ignition and incompatible materials. Storage area should be clearly identified, clear of obstruction and accessible only to trained and authorized personnel. Inspect periodically for damage or leaks.

Incompatible materials: This product forms combustible and/or explosive mixtures with air and/or oxygen. This product is incompatible with strong acids or bases, oxidizing agents, selected amines, alkali metals, anhydrides, chlorine, ethylene oxide, hydrogen peroxide, and organometallic contaminants.

Special packaging materials: Not available.

SECTION 8 — EXPOSURE CONTROLS AND PERSONAL PROTECTION

Ventilation and engineering controls: Use general or local exhaust ventilation to meet TLV requirements. Where explosive mixtures are present, use electrical systems that are safe for use.

Respiratory protection: Respiratory protection is required if the airborne concentration exceeds the TLV. NIOSH-approved respirators, gas masks, or a self-contained breathing apparatus are recommended depending on the airborne concentration levels.

Protective gloves: Gloves impervious to the material are recommended. Advice should be sought from glove suppliers.

Eye protection: Safety goggles to prevent direct contact, irritation, or injury.

Other protective equipment: Uniform, and eyewash station.

Permissible exposure levels: See Section 2.

SECTION 9 — PHYSICAL AND CHEMICAL PROPERTIES

Physical form, colour and odour: Clear, colourless liquid, very mild solvent odour.

Odour threshold: Not Available.

Boiling Point: 160°F (71°C)

Melting/freezing point: Less than -76°F

Vapour pressure: ~112 mm Hg at 20°C

Vapour density (Air=1): ~4.3

Evaporation rate (nBuOAC=1):

pH: Not Available.

Specific gravity (@68°F / 20°C): 1.31 – 1.32

Coefficient of oil/water distribution: Not Available.

Solubility in water (%): 0.25 g/100ml at 20°C

Volatile organic compounds (VOCs): 100%

Percent Volatile by Weight: 100

SECTION 10 — REACTIVITY AND STABILITY DATA

Stability and reactivity: Stable under the recommended storage and handling conditions prescribed. This product forms combustible and/or explosive mixtures with air and/or oxygen. Hazardous polymerization will not occur.

Conditions to avoid: Static discharge, friction, heat, open flame, other sources of ignition, direct sunlight and air.

Materials to avoid: Incompatible materials (see Section 7).

Hazardous decomposition products: Carbon monoxide, carbon dioxide. May release formaldehyde and ethylene glycol in acidic conditions.
SECTION 11 — TOXICOLOGICAL INFORMATION

LD₅₀ (Rat, Oral)  N-Propyl bromide: 4260 mg/Kg, 1,2 epoxybutane: 1180 mg/Kg, t-Butanol: 3500 mg/Kg, Acetonitrile: 2460 mg/Kg

LC₅₀ (Rat Inhalation)  N-Propyl Bromide: 253000 mg/m³/0.5 hr

Routes of exposure: Skin contact, eye contact, absorption, inhalation, and ingestion.

Toxicological data: There is no available data for the product itself, only for the ingredients.

Teratogenicity, mutagenicity, other reproductive effects: None known.

Sensitization to material: None known.

Synergistic materials: Not Available.

Conditions aggravated by exposure: Pre-existing skin disorders, lung (asthma-like) disorders, and liver and kidney disorders.

SECTION 12 — ECOLOGICAL INFORMATION

Environmental effects: The product should not be allowed to enter drains or water courses or be deposited where it can affect ground or surface waters.

Important environmental characteristics: N/A

Aquatic toxicity: There is no data available on the product itself.

SECTION 13 — WASTE DISPOSAL

Handling for disposal: Handle waste according to recommendations in Section 7.

Methods of disposal: Containers should be disposed of in accordance with all applicable federal, provincial, state, and local regulations.

SECTION 14 — TRANSPORTATION INFORMATION

Transportation of Dangerous Goods (TDG) information:

Shipping description: Not Regulated.


International Dangerous Goods information:

ICAO / IATA: Not Regulated.

SECTION 15 — REGULATORY INFORMATION

TSCA information: All components are in full compliance with the TSCA inventory.

SARA

Section 302, 304: None

Section 311, 312: Acute

Section 313 Toxic Chemical: This product contains 1,2 epoxybutane, t-Butanol and Acetonitrile which are subject to reporting requirements of SARA Section 313, Title III.

RCRA: For disposal of unused material check with local, state and federal environmental agencies.

NFPA, HMIS, WHMIS:

Health 1
California Proposition 65: This product contains n-propyl bromide which is known to the state of California to cause reproductive toxicity.

SECTION 16 — OTHER INFORMATION

Legend:  
N/Ap – Not Applicable  
OSHA – Occupational Safety and Health Act  
TLV – Threshold Limit Value  
DOL – Domestic Substances List  
ICAO – International Civil Aviation Organisation  
CEPA – Canadian Environmental Protection Act  
IARC – International Agency for Research on Cancer  
NIOSH – National Institute for Occupational Safety and Health  
ACGIH – American Conference of Governmental Industrial Hygienists  
EPA – United States Environmental Protection Agency  
DOT – United States Department of Transportation  
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act (EPA)  
TDG – Canadian Transportation of Dangerous Goods Act and Regulations

References:  
Canadian Centre for Occupational Health and Safety. CHEMINFO / RTECS database (2001-3)  
Material Safety Data Sheets from manufacturer.

Prepared by: Albatross USA Inc.  
Telephone number: 718-392-6272  
Preparation Date: March 5, 2004  
Revision Date: March 2006

NOTICE:  
The supplier disclaims all expressed or implied warranties of merchantability or fitness for a specific use, with respect to the product or the information provided herein, except for conformation to contracted specifications. All information appearing herein is based upon data obtained from manufacturers and/or recognized technical sources. While the information is believed to be accurate, we make no representations as to its accuracy or sufficiency. Conditions of use are beyond our control, and therefore users are responsible for verifying the data under their own operating conditions to determine whether the product is suitable for their particular purposes and they assume all risks of their use, handling, and disposal of the product. Users also assume all risks in regards to the publication or use of, or reliance upon, information contained herein. This information relates only to the product designated herein, and does not relate to its use in combination with any other material or process.
ii. Trichloroethylene (Stabilized)

1 Safety Data Sheet

STONE ENVIRONMENTAL SERVICES
6160 PURDUE DRIVE
ATLANTA, GA 30336

Date of Preparation: 5/15/2015
Phone: (866-262-2326) email: amid@stoneenv.org

Trichloroethylene (Stabilized)

Section 1 - Chemical Product and Company Identification

Product/Chemical Name: Trichloroethylene (Stabilized for Degreasing)
Chemical Formula: C\textsubscript{3}H\textsubscript{6}Cl\textsubscript{3}
CAS Number: 79-01-6
Other Designations: Ethylene trichloride; 1,1,2-Trichloroethylene; TCE
Emergency Telephone: 1-800-424-9300 - Chemtrec

Section 2 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆
Suspect cancer hazard. May cause cancer. Irritating to eyes and skin. May cause central nervous system effects. Aspiration hazard if swallowed - can enter lungs and cause damage. May cause irritation of respiratory tract. Possible risks of irreversible effects. Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Potential Health Effects
Target Organ: Central nervous system (CNS), Eyes, Respiratory system, Kidney, Heart, Liver, Skin, Blood, spleen

HAZARDS IDENTIFICATION
Classification of the substance or mixture
GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Skin irritation (Category 2), H315
Eye irritation (Category 2A), H319
Germ cell mutagenicity (Category 2), H341
Carcinogenicity (Category 1B), H350
Specific target organ toxicity - single exposure (Category 3), Central nervous system, H336
Acute aquatic toxicity (Category 3), H402
Chronic aquatic toxicity (Category 3), H412
GHS Label elements, including precautionary statements

Signal word: Danger

Hazard statement(s)
H315 Causes skin irritation.
H319 Causes serious eye irritation.
H336 May cause drowsiness or dizziness.
H341 Suspected of causing genetic defects.
H350 May cause cancer.
H412 Harmful to aquatic life with long lasting effects.

Precautionary statement(s)
P201 Obtain special instructions before use.
P202 Do not handle until all safety precautions have been read and understood.
P261 Avoid breathing dust/ fume/ gas/ mist/ vapors/ spray.
P264 Wash skin thoroughly after handling.
P271 Use only outdoors or in a well-ventilated area.
P273 Avoid release to the environment.
Trichloroethylene

P280 Wear eye protection/ face protection.
P280 Wear protective gloves.
P281 Use personal protective equipment as required.
P302 + P352 IF ON SKIN: Wash with plenty of soap and water.
P304 + P340 + P312 IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Call a POISON CENTER or doctor/ physician if you feel unwell.
P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P308 + P313 IF exposed or concerned: Get medical advice/ attention.
P332 + P331 If skin irritation occurs: Get medical advice/ attention.
P337 + P313 If eye irritation persists: Get medical advice/ attention.
P362 Take off contaminated clothing and wash before reuse.
P403 + P233 Store in a well-ventilated place. Keep container tightly closed.
P405 Store locked up.
P501 Dispose of contents/ container to an approved waste disposal plant. 

Hazards not otherwise classified (HNOC) or not covered by GHS - none

Acute Effects
Eye: Causes eye irritation.
Skin: Causes skin irritation. May be harmful if absorbed through the skin.
Ingestion: Aspiration hazard. May be harmful if swallowed. May cause central nervous system effects. Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhea.
Inhalation: Inhalation may cause central nervous system effects. May cause irritation of respiratory tract. May be harmful if inhaled

Chronic: May cause cancer. Tumorigenic effects have been reported in experimental animals. Experiments have shown reproductive toxicity effects on laboratory animals. Possible risks of irreversible effects. May cause adverse liver effects. May cause adverse kidney effects.

Carcinogenicity: The table below indicates whether each agency has listed any ingredient as a carcinogen.

<table>
<thead>
<tr>
<th>Components</th>
<th>ACCGIH</th>
<th>IARC</th>
<th>NTP</th>
<th>OSHA</th>
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<tbody>
<tr>
<td>Trichloroethylene</td>
<td>A2</td>
<td>Group 2A</td>
<td>Reasonably anticipated</td>
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</table>

ACGIH: (American Conference of Governmental Industrial Hygienists)
A1 - Known Human Carcinogen
A2 - Suspected Human Carcinogen
A3 - Animal Carcinogen

IARC: (International Agency for Research on Cancer)
Group 1 - Carcinogenic to Humans
Group 2A - Probably Carcinogenic to Humans
Group 2B - Possibly Carcinogenic to Humans

NTP: (National Toxicity Program)
NTP: (National Toxicity Program)


Section 3 - Composition / Information on Ingredients

<table>
<thead>
<tr>
<th>CAS#</th>
<th>Chemical Name</th>
<th>Percent</th>
<th>EINECS/ELINCS</th>
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<td>79-01-6 Proprietary</td>
<td>Trichloroethylene Stabilizer</td>
<td>&gt;99</td>
<td>201-167-4</td>
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<td></td>
<td></td>
<td>0.1 - 1</td>
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</table>

Appearance/General Info:

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<thead>
<tr>
<th>Chemical Name</th>
<th>ACGIH</th>
<th>NIOSH</th>
<th>OSHA - Final PELs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichloroethylene</td>
<td>10 ppm TWA; 25 ppm STEL</td>
<td>1000 ppm IDLH</td>
<td>100 ppm TWA; 200 ppm Ceiling</td>
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</table>
### Section 4 - First Aid Measures

**Eyes:** Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical aid immediately.

**Skin:** Get medical aid immediately. Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes.

**Ingestion:** If swallowed, get medical aid immediately. Only induce vomiting if directed to do so by medical personnel. Never give anything by mouth to an unconscious person.

**Inhalation:** Get medical aid immediately. Remove from exposure and move to fresh air immediately. If breathing is difficult, give oxygen. Do not use mouth-to-mouth resuscitation if victim ingested or inhaled the substance; induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device.

*After first aid, get appropriate in-plant, paramedic, or community medical support.*

### Section 5 - Fire-Fighting Measures

| Flash Point: | Not applicable |
| LEL: | 8 vol% |
| UEL: | 10.5 vol% |

**Flammability Classification:**

- **Extinguishing Media:** Use agent most appropriate to extinguish fire. Use water spray, dry chemical, carbon dioxide, or appropriate foam.

**Unusual Fire or Explosion Hazards:** Containers may explode when heated. Keep product and empty container away from heat and sources of ignition.

**Hazardous Combustion Products:** Irritating and toxic fumes and gases.

**Fire-Fighting Instructions:** Do not release runoff from fire control methods to sewers or waterways.

**Fire-Fighting Equipment:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full face-piece operated in pressure-demand or positive-pressure mode.

### Section 6 - Accidental Release Measures

**Spill /Leak Procedures:** Eliminate all ignition sources. Ventilate area.

**Small Spills:** Soak up with inert absorbent material. Keep in suitable and closed containers for disposal. Clean up spills immediately, observing precautions in the Protective Equipment section.

**Large Spills:**

- **Containment:** For large spills, dike far ahead of spill for later disposal. Do not release into sewers or waterways.

- **Cleanup:** Avoid generating dusty conditions. Provide ventilation.

**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

### Section 7 - Handling and Storage

**Handling Precautions:** Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Use with adequate ventilation. Avoid contact with eyes, skin, and clothing. Keep container tightly closed. Avoid ingestion and inhalation.

**Storage Requirements:** Store in a tightly closed container. Store in a cool, dry, well-ventilated area away from incompatible substances.

### Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:**

- **Ventilation:** Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (See, 21). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.

**Administrative Controls:**

**Respiratory Protection:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or non-routine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.

**Warning:** Air-purifying respirators do not protect workers in oxygen-deficient atmospheres. If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
Trichloroethylene

**Protective Clothing/Equipment:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.

**Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

**Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment.

**Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

### Section 9 - Physical and Chemical Properties

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<tr>
<th>Property</th>
<th>Value</th>
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<td>Physical State</td>
<td>Liquid</td>
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<tr>
<td>Appearance</td>
<td>Colorless</td>
</tr>
<tr>
<td>Odor</td>
<td>Sweet</td>
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<td>Odor Threshold</td>
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<tr>
<td>pH</td>
<td>No information available</td>
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<tr>
<td>Vapor Pressure</td>
<td>77.3 mbar @ 20 °C</td>
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<tr>
<td>Vapor Density</td>
<td>4.5 (Air = 1.0)</td>
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<td>Boiling Point/Range</td>
<td>87 °C / 188.6 °F</td>
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<td>Melting Point/Range</td>
<td>88°C /122.8°F</td>
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<td>Evaporation Rate</td>
<td>0.69 (Carbon Tetrachloride = 1.0)</td>
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<tr>
<td>Molecular Formula</td>
<td>C₂HCl₃</td>
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### Section 10 - Stability and Reactivity

**Stability:** Trichloroethylene is light sensitive and moisture sensitive.

**Polymerization:** Hazardous polymerization has not been reported.

**Chemical Incompatibilities:** Incompatible products. Excess heat. Exposure to light. Exposure to moist air or water.


**Hazardous Decomposition Products:** Thermal oxidative decomposition of Trichloroethylene can produce hydrogen chloride gas, Chlorine, Phosgene.

### Section 11 - Toxicological Information

**Toxicity Data:**

<table>
<thead>
<tr>
<th>Effect</th>
<th>Description</th>
</tr>
</thead>
</table>
| LC₅₀ Inhalation          | 8000 ppm ( Rat )
4 h; 26300 ppm ( Rat ) 1 h |
Oral, rat: LD₅₀ = 4290 mg/kg; Skin, rabbit: LD₅₀ = 20 g/kg; |

**Mutagenic Effects**

Mutagenic effects have occurred in humans.

**Reproductive Effects**

Experiments have shown reproductive toxicity effects on laboratory animals.

**Developmental Effects**

Developmental effects have occurred in experimental animals.

**Teratogenicity**

Teratogenic effects have occurred in experimental animals.

**Other Adverse Effects**

Tumorigenic effects have been reported in experimental animals. See actual entry in RTECS for complete information.

* See NIOSH, RTECS/KX4450000, for additional toxicity data.

### Section 12 - Ecological Information

**Toxicity**

Toxicity to fish LC₅₀ - Pimephales promelas (fathead minnow) - 41 mg/l - 96.0 h

LOEC - other fish - 11 mg/l - 10.0 d

NOEC - Oryzias latipes - 40 mg/l - 10.0 d

Toxicity to daphnia and other aquatic invertebrates

EE50 - Daphnia magna (Water flea) = 18.00 mg/l - 48 h

Toxicity to algae IC₅₀ - Pseudokirchneriella subcapitata (green algae) - 175.00 mg/l - 96 h

**Persistence and degradability**

No data available

Bioaccumulative potential

Does not bioaccumulate.

**Mobility in soil**

No data available.

**Results of PBT and vPvB assessment**

PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

**Other adverse effects**

An environmental hazard cannot be excluded in the event of unprofessional handling or disposal. Harmful to aquatic life with long lasting effects.

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Page 4 of 6
### Section 13 - Disposal Considerations

**Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

**Disposal Regulatory Requirements:**

**Container Cleaning and Disposal:**

### Section 14 - Transport Information

<table>
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<th>US DOT (49 CFR 172.101)</th>
<th>IATA</th>
<th>IMDG/IMO</th>
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<td>PSN: Trichloroethylene</td>
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<tr>
<td>Trichloroethylene</td>
<td>Hazard Class: 6.1</td>
<td>Hazard Class: 6.1</td>
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</table>

### Section 15 - Regulatory Information

**US FEDERAL**

**TSCA**

CAS# 79-01-6 is listed on the TSCA inventory.

**Health & Safety Reporting List**

None of the chemicals are on the Health & Safety Reporting List.

**Chemical Test Rules**

None of the chemicals in this product are under a Chemical Test Rule.

**Section 12b**

None of the chemicals are listed under TSCA Section 12b.

**TSCA Significant New Use Rule**

None of the chemicals in this material have a SNUR under TSCA.

**CERCLA Hazardous Substances and corresponding RQs**

CAS# 79-01-6: 100 lb final RQ; 45.4 kg final RQ

**SARA Section 302 Extremely Hazardous Substances**

None of the chemicals in this product have a TPQ.

**SARA Codes**

CAS# 79-01-6: immediate, delayed, reactive.

**Section 313**

This material contains Trichloroethylene (CAS# 79-01-6, 99+%), which is subject to the reporting requirements of Section 313 of SARA Title III and 40 CFR

**Clean Air Act**

CAS# 79-01-6 is listed as a hazardous air pollutant (HAP). This material does not contain any Class 1 Ozone depleters. This material does not contain any Class 2 Ozone depleters.

**Clean Water Act**

CAS# 79-01-6 is listed as a Hazardous Substance under the CWA. CAS# 79-01-6 is listed as a Priority Pollutant under the Clean Water Act. CAS# 79-01-6 is listed as a Toxic Pollutant under the Clean Water Act.

**OSHA**

None of the chemicals in this product are considered highly hazardous by OSHA.

**STATE**

CAS# 79-01-6 can be found on the following state right to know lists: California, New Jersey, Pennsylvania, Minnesota, Massachusetts.

**California Prop 65**

The following statement(s) is(are) made in order to comply with the California Safe Drinking Water Act:

**WARNING:** This product contains Trichloroethylene, a chemical known to the state of California to cause cancer.

California No Significant Risk Level: CAS# 79-01-6: 50 æg/day NSRL (oral); 80 æg/day NSRL (inhalation)
Trichloroethylene

European/International Regulations
European Labeling in Accordance with EC Directives

Hazard Symbols:

Risk Phrases:
R 36/38 Irritating to eyes and skin.
R 45 May cause cancer.
R 52/53 Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
R 67 Vapors may cause drowsiness and dizziness.
R 68 Possible risk of irreversible effects.

Safety Phrases:
S 45 In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
S 53 Avoid exposure - obtain special instructions before use.
S 61 Avoid release to the environment. Refer to special instructions /safety data sheets.

WGK (Water Danger/Protection)
CAS# 79-01-6: 3

Canada - DSL/NDSL
CAS# 79-01-6 is listed on Canada's DSL List.

Canada - WHMIS
This product has a WHMIS classification of D1B, D2B.
This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all of the information required by those regulations.

Canadian Ingredient Disclosure List
CAS# 79-01-6 is listed on the Canadian Ingredient Disclosure List.

Section 16 - Other Information

Disclaimer: All information, recommendations and suggestions appearing herein are based upon sources believed to be reliable. However, it is the users responsibility to determine the safety, toxicity and suitability for its own use of this product. STONE ENVIRONMENTAL SERVICES, LLC DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE USE BY OTHERS OF THIS PRODUCT.
Appendix B Risk Assessments

### By-hand AASHTO method Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt, with Stabilized N-Propyl Bromide as solvent.

#### Table

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Preheat muffle furnace to 110°C.</td>
</tr>
<tr>
<td>2</td>
<td>Insert sample into muffle furnace.</td>
</tr>
<tr>
<td>3</td>
<td>Close muffle door and let stand for 1 hour.</td>
</tr>
<tr>
<td>4</td>
<td>Remove sample from muffle furnace.</td>
</tr>
<tr>
<td>5</td>
<td>Weigh sample and record weight.</td>
</tr>
</tbody>
</table>

#### Form

- **Date:** [Date]
- **Location:** [Location]
- **Person:** [Name]

#### Risk Assessment Tool

<table>
<thead>
<tr>
<th>Score</th>
<th>Risk Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Low</td>
</tr>
</tbody>
</table>

**Recommended Actions:**

- [Action 1]
- [Action 2]
- [Action 3]

**Notes:**

- [Note 1]
- [Note 2]
ii. Asphalt Analyzer (machine) method AASHTO method Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt, with Trichloroethylene as solvent.
APPENDIX B
Test Results
<p>| Lab Number | Method | Tester | Sample Wt. (g) | % Binder | Wash Cycles | Gradation 1 1/2&quot; | Gradation 1&quot; | Gradation 3/4&quot; | Gradation 1/2&quot; | Gradation 3/8&quot; | Gradation #4 | Gradation #8 | Gradation #16 | Gradation #30 | Gradation #50 | Gradation #100 | Gradation #200 | Gsa | %Abs | Gsb | FAA |
|------------|--------|--------|----------------|----------|-------------|------------------|---------------|----------------|----------------|----------------|--------------|------------|-------------|-------------|-------------|--------------|----------------|--------------|-----|------|-----|-----|
| ABC6-0030  | T164   | N/A    | 1803.5         | 4.48     | 11          | 100              | 97            | 91             | 75             | 60             | 50           | 38         | 23          | 15          | 12          | 2.697        | 1.83         | 2.570         | 42.0         |
| ABC6-0030  | Mod    | Jon    | 2071.3         | 4.38     | 11          | 100              | 97            | 92             | 76             | 58             | 49           | 37         | 23          | 16          | 14          | 2.697        | 1.61         | 2.585         | 41.7         |
| ABC6-0030  | Mod    | Jon    | 1735.8         | 4.30     | 11          | 100              | 98            | 92             | 74             | 59             | 47           | 35         | 21          | 13          | 11          | 2.687        | 1.50         | 2.583         | 42.4         |
| ABC6-0030  | Inf-1  | Jon    | 1721.1         | 4.47     | 11          | 100              | 97            | 94             | 76             | 59             | 46           | 34         | 19          | 12          | 11          | 2.682        | 1.50         | 2.578         | 43.5         |
| ABC6-0030  | Inf-2  | Jon    | 1709.5         | 4.45     | 11          | 100              | 97            | 93             | 75             | 59             | 48           | 36         | 22          | 14          | 11          | 2.691        | 1.42         | 2.592         | 42.5         |
| ABC6-0030  | Inf-3  | Jon    | 1637.7         | 4.38     | 11          | 100              | 97            | 92             | 75             | 59             | 46           | 34         | 19          | 12          | 11          | 2.684        | 1.62         | 2.573         | 43.4         |
| ABC6-0030  | Inf-4  | Jon    | 1733.9         | 4.64     | 11          | 100              | 98            | 93             | 77             | 61             | 49           | 37         | 22          | 14          | 11          | 2.693        | 1.51         | 2.588         | 42.5         |
| ABC6-0030  | Inf-5  | Jon    |                 |          |             |                   |               |                |                |                |              |            |             |             |             |              |              |                |              |</p>
<table>
<thead>
<tr>
<th>Lab Number</th>
<th>Method</th>
<th>Tester</th>
<th>Sample Wt. (g)</th>
<th>% Binder</th>
<th>Wash Cycles</th>
<th>Gradation</th>
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<td>ABC6-0031</td>
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<td>T164 Mod</td>
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<table>
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<th>% Binder</th>
<th>Wash Cycles</th>
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<td></td>
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<p>|          | 2.741      | 2.740   |
|          | 2.738      | 2.738   |
|          | 2.745      | 2.733   |
|          | 2.738      | 2.738   |
|          | 2.36       | 2.24    |
|          | 2.28       | 2.28    |
|          | 2.35       | 2.35    |
|          | 2.38       | 2.38    |
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