Section 962

GUIDELINES FOR STONE MATRIX ASPHALT (SMA) MIX DESIGN AND VERIFICATION

962.01 Scope

This procedure provides guidelines for designing a mix for Stone Matrix Asphalt (SMA). The Contractor will perform and submit the mix design according to the specification and this Manual of Instruction; the Department will verify the mix design.

REFERENCES:

AASHTO STANDARDS:

M 231	Weighing Devices used in the Testing of Materials
M 325	Stone Matrix Asphalt (SMA)
R 28	Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV)
R 30	Mixture Conditioning of Asphalt Mixtures
R 46	Designing Stone Matrix Asphalt (SMA)
T 19	Bulk Density ("Unit Weight") and Voids in Aggregate
T 30	Mechanical Analysis of Extracted Aggregate
T 84	Specific Gravity and Absorption of Fine Aggregate
T 85	Specific Gravity and Absorption of Coarse Aggregate
T 166	Bulk Specific Gravity (G_{sb}) of Compacted Hot Mix Asphalt (HMA) Using Saturated-Surface Dry Specimens
T 209	Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)
T 240	Effect of Heat and Air on a Moving Film of Asphalt Binder (Rolling Thin-Film Oven Test)
T 305	Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures
T 308	Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
T 312	Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor
T 313	Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)
T 315	Determining the Rheological Properties of Asphalt Binder Using the Dynamic Shear Rheometer (DSR)

ASTM STANDARDS:

D 4402	Viscosity Determinations of Asphalt at Elevated Temperatures Using a Rotational

Viscometer

D 4753 Evaluating, Selecting, and Specifying Balances and Standard Masses for use in Soil, Rock, and Construction Materials Testing

NAPA Quality Improvement Series Publication 122: Designing and Constructing SMA Mixtures – State-of-the-Practice

UDOT MATERIALS MANUAL OF INSTRUCTION (MOI)

UDOT MINIMUM SAMPLING AND TESTING REQUIREMENTS

962.02 Significance and Use

The objective of the SMA mix design is to determine the combination of asphalt binder and aggregates that will give long lasting performance as part of the pavement structure. Mix design involves laboratory procedures developed to establish the necessary proportion of materials for use in SMA. Well-designed asphalt mixtures can be expected to serve successfully for many years.

The mix design of SMA is just the starting point to assure that an asphalt concrete pavement will perform as required. Together with proper construction practice, mix design is an important step in achieving well-performing asphalt pavements. In many cases, the cause of poor performing pavements has been attributed to poor or inappropriate mix design or to the production of a mixture other than what was designed in the laboratory. To that end, it is critical that the materials and proportions used in the design are representative of the materials and proportions that will be used in the pavement structure.

The purpose of the Mix Design Verification Process is to provide an independent review of the Contractor's mix design. The verification process may consist of any, or all of the following:

- A review of the Contractor's design submittal documentation
- A review of the project history of a previously used SMA design
- A duplication of the Contractor's laboratory effort to verify individual mix components and/or total mix properties

962.03 Stone Matrix Asphalt Mix Design Guidelines

Asphalt binder, aggregate and mix properties are defined by project specification, including, but not limited to:

- VMA
- Design air void content (V_a)
- PG asphalt binder grade
- Hamburg Wheel-Track Testing (HWTT) (MOI 8-990) - (replaces Tensile Strength Ratio (Lottman))
- Flakiness Index (MOI 8-933)-(replaces Flat and Elongated Particles)
- Gyratory mixing and compaction temperatures

962.04 Standard Practice for Stone Matrix Asphalt Mix Design

The contractor will perform the mix design according to *AASHTO M 325: Standard Specification for Stone Matrix Asphalt* with the following additions:

- Use a UDOT Laboratory Qualification Program qualified laboratory for HMA.
- Use a Superpave Gyratory Compactor approved according to MOI 8-961: Guidelines for Superpave Gyratory Compactor Protocol.
- Use gyratory mixing and compaction temperatures supplied by the Engineer.
- Use a Hamburg Wheel Track Testing lab approved by the Department.
- Meet all mix design requirements in the specifications for the selected target gradation.
- Perform mortar testing according to this MOI Appendix B.
- Minimum asphalt binder content will be according to specification.
- Do not use Recycled Asphalt Pavement (RAP).
- Incorporate hydrated lime into all mix designs according to project specifications.
    - Use 1 percent, minimum, for Method A and 1 ½ percent, minimum for Method B.
    - Prepare laboratory samples in a manner similar to field production.
- Refer to NAPA Quality Improvement Series Publication 122: Designing and Constructing SMA Mixtures – State-of-the-practice for additional information.

The mix design will be performed using materials intended for use on the project. Materials used in the mix design will meet the following criteria:

- **Asphalt binder** shall be obtained from a certified supplier meeting the requirements outlined in the UDOT *Quality Management Plan 509: Asphalt Binder Management System*. For mix design verifications, the Region Labs will obtain pre-qualified binder from the UDOT Asphalt Binder Lab.
- **Hydrated lime** shall be obtained from a certified supplier meeting the requirements outlined in *Quality Management Plan 510: Hydrated Lime Management System.* The hydrated lime will be accompanied by test results or will be pre-tested by the Central Materials Laboratory prior to use in the mix design verification.

Submit the Volumetric Mix Design data for verification at least 10 working days before beginning paving. Do not begin paving until verification is complete.

- Include all information regarding selection of design aggregate structure showing the target values of percent passing on all sieves listed in the specification, and the design asphalt binder content.
- Provide information that aggregate proposed for use meet the requirements of /AASHTO M 325 and the specification.
- Supply QC data for target job mix gradation selection.
- Run 4 sets of 2 Gyratory specimens at the design asphalt binder content to verify the optimum

asphalt and all other design requirements after the design is complete.

The laboratory performing the mix design or its subcontractor will perform and report the Hamburg Wheel Track Testing of Compacted Hot-Mix Asphalt (MOI 8-990). Submit the complete test record in Standard Department format to the UDOT**.**

UDOT may verify the results by performing an additional test to be run on slabs or pucks at its discretion. Refer to 962.05 for material submittal.

962.05 Mix Design Verification Process

General:

The Department performs mix design verification; the verification process outlined in this document is intended to be complete. However, verification could include any or all tests identified in AASHTO M 325, project specifications, project special provisions, the current MOI, the current *Minimum Sampling and Testing Requirements* or other aggregate quality, volumetric, or mix performance tests that may be added in the future. All materials submitted for use in the verification process are required to be representative of those used in the mix design.

The Contractor will submit the mix design data and materials samples for verification at least 10 working days before beginning paving. Paving will not begin until verification is complete. "Working days" refer to Monday through Friday, excluding state holidays, and begin when all the following are submitted to the Region Laboratory:

- Mix Design Report
- *All* aggregate quality test results
- *All* pre-blended aggregate samples
- *A sufficient quantity* of the hydrat*ed lime*
- *A sufficient quantity* of the stabilizing additive
- *A sufficient quantity mineral filler*
- Test Report for hydrated lime
- Asphalt binder to Central Materials Lab
- Hamburg Wheel Tracker Test results

"Working days" end when the Region Materials Engineer (RME) provides a **Mix Design Review Report** to the Resident Engineer.

962.05.01 Contractor Submittals

Mix Design Report - The Contractor will submit the Mix Design Report to the RME. The Contractor will submit a Mix Design Report Summary and Transmittal Letter to the Resident Engineer (RE). The submittals should follow the outline and example in Appendix "A."

A verified mix design may be submitted for use on a project other than the project originally identified. The Contractor will submit the Verified Mix Design Report to the RME and a Mix Design Report Summary and Transmittal Letter to the RE for the new project. **Both reports must include documentation regarding field changes made after original verification.**

Pre-Blended Samples - The Contractor will prepare samples for use in the verification process. The pre-blended samples, stabilizing additive, mineral filler and hydrated lime are submitted to the RME. The Contractor will provide additional samples upon request.

> ***Note:*** Asphalt binder for mix design verification will be supplied to the Region Materials Lab from Central Materials Lab.

A pre-blended sample is a blend of the final aggregate structure, without stabilizing additive, mineral filler, hydrated lime, and asphalt binder. Pre-blended samples are made at the required sample size by recombining the aggregate portion that has been sieved into individual sieve size fractions. Larger samples split to sample size are not acceptable.

The final gradation of the mix includes the stabilizing additive and hydrated lime, as per specification. Mix design verification may include a sieve analysis of the virgin materials and/or of the post-ignition final gradation.

The following tolerances from target gradation for each sieve will be allowed:

1/2 inch 2%

3/8 inch 2%

No. 4 ....2%

No. 8 ....1%

No. 16 ....1%

No. 30 ....1%

No. 50 ....1%

No. 200 ....0.8%

Initial pre-blended samples to be submitted:

10 Samples – Gyratory Compaction – AASHTO T 312 (100 gyrations)

5 Samples – G_{mm} Determination – AASHTO T 209

5 Samples – Draindown – AASHTO T 305

½ ft^3 plus No. 4 aggregate blend – Dry Rodded Unit Weight – AASHTO T 19

2 Samples – Hamburg Wheel Track Testing – MOI 8-990

- Prepared as above (not mixed)
- Sufficient material for two 12”x12”x1.5” slabs

Samples to be submitted after the mix is verified:

2 sets of 5 Asphalt Binder Correction Samples per ignition oven, **AASHTO T 308 at least three working days before paving**

Samples are submitted at mix design binder content and gradation: blend the final aggregate structure with hydrated lime, stabilizing additive, mineral filler, and asphalt binder according to MOI 8-988 before submitting. Follow Method A of T 308; in general do not use Note 6. The printed ticket from the oven should be used.

962.05.02 Verification Process

The Region materials laboratory will obtain appropriate asphalt binder for mix design verification from the Central Materials Laboratory. For tests performed on the HMA, the submitted material will be mixed according to MOI 8-988 and aged for “Volumetric Mix Designs” according to AASHTO R 30.

The following tests will be performed on submitted material during the verification procedure.

To verify the mix design volumetric properties, verify the volumetric properties determined by the Region material laboratory and the Contractor determined properties are within the “Precision and Bias” statement of the AASHTO procedure for acceptable multi-laboratory precision. See Appendix D.

G_{mb} – determined on 3 sets of 2 gyratory specimens – AASHTO T 312 (100 gyrations) and T 166

G_{mm} – AASHTO T 209

Hamburg Wheel Track Testing – MOI 8-990

Final mix gradation – AASHTO T 30

- The gradation will be evaluated for compliance with the specifications.
- The stockpile gradations and blending percentages must be submitted and may be verified by the Region and compared to the submitted data.

The following tests may be performed on submitted material during the verification procedure.

G_{sb} – fine and coarse aggregate specific gravities – AASHTO T 84 and T 85

The following information may be evaluated on the submitted Mix Design:

Air Voids

Asphalt Binder Grade

VMA

$VCA_{MIX} < VCA_{DRC}$

Mortar quality tests

Draindown

Aggregate Quality Tests

Hydrated Lime

Stabilizing additive

Mineral filler

Any or all of the quality verification tests may be revisited during production. If any of the aggregate quality tests do not meet the specified criteria, production shall be halted and the issue addressed.

962.05.03 Mix Design Performance Testing

Hamburg Wheel Track Testing of Compacted Bituminous Mixtures MOI 8-990 is a mix design requirement performed by the Mix Design Laboratory or its approved subcontractor. The Region Materials Laboratory may perform this test to verify the submitted results after a mix has been verified. The Region Lab will follow the procedure in MOI 8-990 for Slabs or Pucks at its discretion. The Region Lab will obtain appropriate asphalt binder from the Central Materials Laboratory.

962.05.04 Mix Design Re-Verification

The RME may choose to approve a previously verified mix design through a review of documentation of the original verification process. The documentation must include results of Hamburg testing. The RME may also require project performance data from use on previous projects.

- **The RME may elect to require re-verification of Hamburg Wheel Tracker performance.**

The RME will re-evaluate any mix design(s) at any indication of significant changes to the total mix properties and/or any individual component. A complete re-evaluation of SMA mix designs will occur at a minimum of every two years.

962.05.05 Field Mix Design Verification

The RME may allow a field verification option of the mix design. The Region or Satellite Lab performs the tests for field verification on material placed on an independent test strip outside of the project limits. The verification laboratory is required to perform an ignition oven calibration before field mix design verification in order to determine accurate field asphalt binder content.

To verify the mix design, the following tests are performed on samples obtained in accordance with MOI 8-984, and reduced in accordance with MOI 8-985.

G_{mb} – determined on a minimum of 3 sets of 2 gyratory specimens – AASHTO T 312 (100 gyrations) and T 166

G_{mm} – AASHTO T 209

$VCA_{MIX} < VCA_{DRC}$ – determined on a minimum of 3 sets of 2 gyratory specimens – AASHTO T 312 (100 gyration) and T 19

% Asphalt Binder Content – AASHTO T 308 Method A

Gradation of residual aggregate – AASHTO T 30 – performed on the remaining T-308 sample

Hamburg Wheel Track Testing of Compacted Bituminous Mixtures – MOI 8-990

Draindown - AASHTO T 305

Should the test results not meet specification the supplier may make adjustments and the process repeated. The mix design is “Not Verified” if test results fail to meet specification targets after the second attempt. Expected lab testing variability is considered by the RME on these requirements.

962.05.04 Mix Design Review Report

After the verification process is complete, the RME will place a written summary report in the materials database as notification of the results. The Mix Design Review Report will indicate whether the mix design has been:

- **Verified as Submitted**
- **Verified with Conditions**
- **Not Verified**

Results of **"Verified with Conditions"** and **"Not Verified"** will include an explanation of conditions and/or deficiencies. The Mix Design Review Report will also contain a summary of the region laboratory test results and necessary construction information. The materials database contains the necessary report form.

APPENDIX A

INFORMATION OUTLINE FOR CONSULTANT / CONTRACTOR

MIX DESIGN REPORT

First Two/Three Pages of Design Submitted Shall Include the Following Mix Design Information:

- Date
- Laboratory Name
  - Accreditation / credentials (AASHTO RE:SOURCE/UDOT approved)
- Laboratory technicians
  - Credentials (UDOT certified)
- UDOT project name and number
- Nominal gradation size
- Gyratory compactor: brand / model
- Asphalt binder
  - PG grade
  - Asphalt binder source
  - Asphalt binder specific gravity - G_b
- Hydrated lime source
- Measured Physical Properties
  - Optimum asphalt binder content percentage
  - VMA (percent by weight of total mix)
  - VCA_{MIX} and VCA_{DRC}
  - No. 4Aggregate blend specific gravity (G_{sb})
  - Draindown results
  - Unaged DSR G*/sin delta
  - RTFO aged DSR G*/sin delta
  - PAV aged BBR Stiffness
  - Hydrated lime percentage
  - Percent stabilizing additive required

  - Percent mineral filler required
  - Bulk specific gravity - G_s
  - Maximum specific gravity - G_{mm}
  - Target gradation
  - .45 power curve graph of Target gradation
- Hamburg Wheel Tracker –
  - Data output in Department standard format
  - Plot of maximum rut depth data set for each wheel or single wheel test
  - Report of rut depth according to MOI 8-990
- Aggregate
  - One fracture face Count
  - Two fracture face Count
  - Fine aggregate angularity
  - Flakiness
  - L.A. wear
  - Sand equivalency (pre-wet method) natural fines percentage
  - Unit weight
- Additional aggregate source information
  - Sodium soundness
  - Clay lumps and friable particles
  - Plasticity index
- Gradation
  - Stockpile percentages
  - Stockpile specific gravities (G_{sb}) and absorptions
  - Hydrated lime specific gravity and percentage
  - Target gradation
  - Plotted gradation
- Gyratory design
  - Calibrated gyratory angle
  - Calibrated gyratory pressure

    - Specimen heights

Reported elsewhere in the submittal:

- Results of all trial gradations
    - Plotted on 0.45 power curve
    - Target Gradations
        - Volumetric properties for each trail blend and optimum asphalt binder content
- Maximum specific gravity - G_{mm}
- Specimen heights
- Pressure applied
- Percent of maximum specific gravity

APPENDIX B

TESTING OF STONE MATRIX ASPHALT MORTARS

This method describes blending and specimen preparation of stone matrix asphalt (SMA) mortars to predetermine the physical characteristics of mortars. Mortar is the dust (minus No. 200 material) from the mix combined with the asphalt binder and fiber.

Apparatus for Preparation

1. Balance: 2-kg capacity, sensitive to 0.1 g. Conform to the requirement of ASTM D 4753, class GP2 or AASHTO M 231, class G2.
2. Oven: capable of maintaining the required temperature within ± 6 degrees C.
3. Hot plate: at least 700-W capacity with adjustable temperature control.
4. Sample containers: capable of holding at least 100 g of filler and 200 g of liquid asphalt binder. A seamless ointment tin is recommended.
5. Mixing tools: wooden tongue depressors, spatulas, and spoons.
6. Insulated gloves: for handling hot samples and equipment.

Sample Preparation Procedure

1. Dry respective aggregate fractions containing material passing the No. 200 sieve to constant weight (mass) at 110 ± 6 degrees C. Dry sieve these aggregates and collect the dust from each aggregate. Blend the fillers to meet the percent by volume on the job-mix-formula. An example of how to blend by volume can be found in AASHTO R 46.
2. Place a quart can of pre-aged liquid asphalt binder into an oven set at 165 ± 6 degrees C. Refer to this Section, Article 2.5 paragraph D.
3. Weigh 100 ± 0.1 g of minus No. 200 blended filler into the sample container and place into a 175 ± 6 degrees C oven. Leave the material in the oven for at least 30 minutes.
4. Weigh into the filler the proper amount of liquid asphalt binder to the nearest 0.1 g.
5. Place the tin on the hot plate and hand mix with a spatula. Slowly add the proper amount of fiber (weighed to the nearest 0.1 g) and continue mixing until the mortar is homogeneous.
6. Use loose fiber of the same type to create the mortar or use a high-shear mixer when asphalt-fiber pellets are used. Asphalt-pellet fibers will not blend into the filler under low-shear mixing conditions.

Testing of Mortars

1. Age the liquid asphalt binder according to AASHTO T 240, AASHTO R 28, or both when performing Performance Grade Asphalt Binder testing of the mortar and before blending with fillers and fibers.
2. Perform ASTM D 4402 except take readings as soon as the temperature stabilizes because the fillers will sink to the bottom over time.
3. Perform AASHTO T 315 except use a preheat temperature of 60 degrees C to insure the specimen will adhere strongly to both plates.

4. Perform AASHTO T 313 except, using aluminum molds:
    a. Place the mold over the corner of the warm hot plate so that the mold is on the hot plate and the rubber O-rings are not.
    b. Gently tamp the mortar into the mold using a wooden tongue depressor. A light coating of release agent (glycerin and talc) will assist in this procedure.
    c. Repeat step b until the mold is full of mortar.
    d. Continue according to AASHTO T 313.

Reporting

- Report as required in this MOI Appendix A

APPENDIX C TO MOI 962

SMA EQUATIONS

The dry weight of virgin aggregate may or may not include the mineral filler. If the mineral filler is not introduced before the pugmill, it is not considered part of the dry weight of virgin aggregate.

Quantity of lime:

$$Lime, g = (Dry\ weight\ of\ virgin\ aggregate, g)\left(\frac{Lime, \%}{100}\right)$$

Total Mineral Filler

$$Mineral\ filler, g = Mineral\ filler, \% \times Dry\ weight\ of\ virgin\ aggregate, g$$

Quantity of Fiber, g – (Fiber content is expressed as a percentage of the total mix. An estimated total mix can be calculated or the contractor can supply this value; i.e 2000 g per G_{mm} determination, 4800 g per gyratory specimen, etc.)

Estimated total sample weight before introduction of fiber:

$$binder\ divisor = \frac{100 - asphalt\ binder, \%}{100}$$

$$estimated\ sample\ mix\ weight = \frac{agg, lime, amd\ mineral\ filler; g}{binder\ divisor}$$

$$fiber, g = estimated\ sample\ mix\ weight \times \frac{fiber, \%}{100}$$

Actual sample weight:

$$actual\ sample\ mix\ weight = \left(\frac{aggregate, lime, mineral\ filler, and\ fiber}{binder\ divisor}\right)$$

$$binder\ weight = asphalt\ binder\ \% \times total\ sample\ weight$$

Example:

Target asphalt binder content, percent total mix	=	6.5%
Mineral Filler (MF), percent of aggregate and lime	=	6%
Fiber content, percent of total mix	=	0.5%
Lime content, percent of virgin aggregate	=	1%
Dry weight of virgin aggregate	=	1800.0 g

$$lime, g = 1800.0g \times \left(\frac{1\%}{100}\right) = 18.0\ g$$

$$aggregate\ with\ lime = 1800.0\ g + 18.0\ g = 1818.0\ g$$

$$mineral\ filler, g = 1818.0\ g \times \left(\frac{6\%}{100}\right) = 109.1\ g$$

$$aggregate, lime\ and\ mineral\ filler = 1818\ g + 109.1\ g = 1927.1\ g$$

$$binder\ divisor = \left(\frac{100 + 6.5\%}{100}\right) = 0.935$$

$$estimated\ sample\ mix\ weight = \left(\frac{1927.1\ g}{0.935}\right) = 2061.1\ g$$

$$total\ fiber, g = 2061.1\ \times \left(\frac{0.5\%}{100}\right) = 10.3\ g$$

$$Total\ sample\ weight = \left(\frac{1927.1\ g + 10.3\ g}{0.935}\right) = 2072.1\ g$$

$$asphalt\ binder\ weight = 6.5\% \times 2072.1$$

Asphalt binder weight =134.7 g.

Total sample weight verification:

Material	Mass
Aggregate	1800.0
Lime	18.0 g
Mineral filler	109.1
Total fiber	10.3
Asphalt binder	134.7 g
Total sample weight (sum of masses)	2072.1

Appendix D to MOI 962
Mix Design Precision Limits Gmb and Gmm

# of Samples	Multiplier of Standard Deviation or Coefficient of Variation per ASTM C670 15, Table 1	Multiplier of Standard Deviation or Coefficient of Variation (Rounded)	Gmb T 166		Gmm T 209 (Rice)	
	Condition of Test		Single lab	Multi lab	Single lab	Multi lab
	Standard Deviation (s)		0.002	0.006	0.0051	0.0084
1						
2	2.771808	2.8	0.006	0.017	0.014	0.023
3	3.314493	3.3	0.007	0.020	0.017	0.028
4	3.633160	3.6	0.007	0.022	0.019	0.031
5	3.857656	3.9	0.008	0.023	0.020	0.032
6	4.030092	4.0	0.008	0.024	0.021	0.034
7	4.169554	4.2	0.008	0.025	0.021	0.035
8	4.286309	4.3	0.009	0.026	0.022	0.036
9	4.386509	4.4	0.009	0.026	0.022	0.037
10	4.474124	4.5	0.009	0.027	0.023	0.038
11	4.551864	4.6	0.009	0.027	0.023	0.038
12	4.621655	4.6	0.009	0.028	0.024	0.039
13	4.684920	4.7	0.009	0.028	0.024	0.039
14	4.742732	4.7	0.009	0.028	0.024	0.040
15	4.795924	4.8	0.010	0.029	0.024	0.040
16	4.845154	4.8	0.010	0.029	0.025	0.041
17	4.890951	4.9	0.010	0.029	0.025	0.041
18	4.933745	4.9	0.010	0.030	0.025	0.041
19	4.973892	5.0	0.010	0.030	0.025	0.042
20	5.011689	5.0	0.010	0.030	0.026	0.042
22	5.081193	5.1	0.010	0.030	0.026	0.043
24	5.143852	5.1	0.010	0.031	0.026	0.043
26	5.200850	5.2	0.010	0.031	0.027	0.044
28	5.253094	5.3	0.011	0.032	0.027	0.044
30	5.301290	5.3	0.011	0.032	0.027	0.045
32	5.346000	5.3	0.011	0.032	0.027	0.045
34	5.387678	5.4	0.011	0.032	0.027	0.045
36	5.426697	5.4	0.011	0.033	0.028	0.046
38	5.463363	5.5	0.011	0.033	0.028	0.046
40	5.497935	5.5	0.011	0.033	0.028	0.046
50	5.646026	5.6	0.011	0.034	0.029	0.047
60	5.764388	5.8	0.012	0.035	0.029	0.048
70	5.862730	5.9	0.012	0.035	0.030	0.049
80	5.946701	5.9	0.012	0.036	0.030	0.050
90	6.019871	6.0	0.012	0.036	0.031	0.051
100	6.084638	6.1	0.012	0.037	0.031	0.051