Federal Motor Vehicle Safety Standard (FMVSS) 202a - Head Restraints

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PRESENTERS

- BSEE
- MGA Associate since 1993
- Quality Manager
- Extensive safety testing experience

- BSEE
- MGA Associate since 2006
- FMVSS 202a (Static) Test Engineer

- BSME
- MGA Associate since 2007
- FMVSS 202a (Dynamic) Test Engineer
• Independent test services
• Began in New York, 1977
• ISO/IEC 17025:2005 Accredited
• Specialize in Safety Regulations (FMVSS, ECE, SAE, ASTM, MIL_STD, etc.), Vibration, Noise, Life Cycle, Environmental, Equipment, etc.
• Industries served include: Automotive, Military, Aerospace, Rail, Other Transportation, etc.
MGA and 202a

- 2nd year of NHTSA test contract (Static Option), 9th year of testing to 202a requirements
- Conduct over 1,200 tests per year for static and dynamic options
- Internal test procedures developed using the OVSC procedure (TP-202aStatic-00 dated 12/22/04) along with the latest changes to the CFR and customer projects
- Work with virtually every OEM, Tier 1 and Tier 2 suppliers, after-market suppliers
- Numerous MGA FMVSS 202a Static test systems have been installed around the world
WEBINAR OVERVIEW

• Introduction
• Compliance Options
  • Static vs. Dynamic Criteria
  • FMVSS 202a S4.2 Static Option
  • FMVSS 202a S4.3 Dynamic Option
• Conclusions
• Question and Answer
INTRODUCTION
INTRODUCTION

• Abbreviations / Acronyms
  • NHTSA – National Highway Traffic Safety Administration
  • FMVSS – Federal Motor Vehicle Safety Standard
  • OVSC – Office of Vehicle Safety Compliance
  • CFR – Code of Federal Regulations
  • DSP – Designated Seating Position
  • SRP – Seating Reference Point
  • O/B – Outboard
  • HRMD – Head Restraint Measuring Device
  • S/B – Seat Back
  • H/R – Head Restraint
  • ATD – Anthropomorphic Test Dummy
INTRODUCTION

- Whiplash injury statistics and studies of the effectiveness of the head restraints to avoid whiplash injuries led to FMVSS 202a.
- In 2001, the NHTSA estimated that:
  - “the reduction of injuries attributable to the proposed front seat head restraint requirements would be 9,575 fewer injuries per year”*.
  - “For the rear seat, the proposed head restraint requirement, which would require head restraints to be installed at locations where they were not previously required, would result in 4,642 fewer injuries per year”*.
- Total estimated benefits from just the increased height requirement alone would be a reduction of 14,247 whiplash injuries each year*.

* Data taken from the 202a NPRM dated 1/4/01
INTRODUCTION

- Notice of Proposed RuleMaking (NPRM) was published on 01/04/01.
- Final rules were published (12/07/04, 03/09/06, and 05/04/07).
- Current OVSC procedure is not updated with the latest CFR changes.
  - TP-202a-Static-00 (dated 12/22/04)
  - TP for Dynamic Option has not been released yet.
INTRODUCTION

• S1. Purpose and scope. This standard specifies requirements for head restraints to reduce the frequency and severity of neck injury in rear-end and other collisions.

• Two-year compliance phase-in:
  - Front Seats:
    - 80% of the vehicle fleet must comply by Sept. 1, 2009
    - 100% by Sept. 1, 2010
  - Rear Seats (if equipped with O/B H/R):
    - 80% of the vehicle fleet must comply by Sept. 1, 2010
    - 100% by Sept. 1, 2011
INTRODUCTION

- Applies to all outboard designated seating positions equipped with a head restraint.

- *Head restraint* means a device that limits the rearward displacement of a seated occupant's head relative to the occupant's torso.

- Minimum requirements which distinguish a seat back from a head restraint are specified.

- Enhances current safety requirements and establishes new criteria such as backset and height retention locks.
COMPLIANCE
OPTIONS
COMPLIANCE OPTIONS

- Manufacturers must specify the compliance option for each O/B DSP in a vehicle.
  - S4.2 Dimensional, Static, and Dynamic Component Tests
  - S4.3 Dynamic Sled and S4.2.2 Width
- Other requirements applicable to all vehicles include:
  - S4.1 (Front O/B DSPs must be equipped with a H/R that complies with S4.2 or S4.3)
  - S4.4 (Rear Seat Non-use positions)
  - S4.5 (Removability)
  - S4.6 (Compliance Option Selection)
  - S4.7 (Owner’s Manual)
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<th>Static Option</th>
<th>Dynamic Option</th>
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<td>✓</td>
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<td>S4.2.1 – Height</td>
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COMPLIANCE OPTIONS

• H/R styles vary greatly depending on occupant location and design.

• New technologies incorporated in head restraint designs generally indicate which option is chosen.

• At this point, there are no exemptions for specific types of head restraints with respect to the various tests.

• Compliance testing will be conducted using a full vehicle.
Types of head restraints in use today include:

- **Adjustable (2-way)** – manual or power with at least two use positions
- **Articulating (4-way)** – manual or power with at least two use positions vertically and horizontally
- **Integrated** – designed as an extension of the seat back
- **Fixed** – one use position (may fold, stow or retract)
- **Active** – pyrotechnic or mechanical device that maintains the backset condition during a rearward crash event
FMVSS 202a S4.2
STATIC OPTION
S4.2 Static Test Procedure

1. Two seats are required for one complete S4.2 test series. Each occupant is tested separately.

2. Determine the fore/aft and vertical adjustment position that produces the highest H-Point relative to the seat back.

3. Measure the test sample to determine the H-Point, height, width, backset, and gaps (3 iterations required).

4. After the seats are measured, use one of the samples to determine height retention and energy absorption.

5. Use the second sample to determine the backset retention, displacement, and strength.
S4.2 Static Test Procedure

Keep in mind:

- Each of the three S4.2 Static Option tests require information and/or measurements obtained during the dimensional evaluation.
- Not all tests required for the S4.2 Static Option can be conducted on the same test sample.
- Vehicle seat mount coordinates and seat design position information is required prior to testing.
<table>
<thead>
<tr>
<th>Test Equipment</th>
<th>202A Sec. 4.2.</th>
<th>Test Desc.</th>
<th>Test Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-Point Machine and ICBC Head Restraint Measuring Device (HRMD)</td>
<td>(1a) Minimum Height – Front Outboard H/R</td>
<td>Uses the H-Point machine with a design torso angle and highest achievable H-point.</td>
<td>Front: 800 mm at a minimum of one position.</td>
</tr>
<tr>
<td></td>
<td>(1b) Minimum Height – All Outboard H/R</td>
<td></td>
<td>Front and Rear: 750 mm at all H/R positions.</td>
</tr>
<tr>
<td></td>
<td>(2) Width</td>
<td></td>
<td>170 mm – Bucket and Rear 254 mm – Front Seats with a Center Occupant</td>
</tr>
<tr>
<td></td>
<td>(3) Backset – Front O/B H/R Only</td>
<td></td>
<td>Less than 55 mm btw. 750-800 mm H/R height.</td>
</tr>
<tr>
<td>165 mm Hemispherical Headform or 25 mm Cylinder</td>
<td>(4) Gaps – Within H/R and Between H/R and Seat</td>
<td>Dimensional measurements only.</td>
<td>No gap &gt; 60 mm at full down H/R position and any backset. 25 mm Cylinder cannot pass through the bottom of the S/B and the top of the H/R (adjustable type only).</td>
</tr>
</tbody>
</table>
FMVSS 202a S4.2 STATIC OPTION

S4.2 (.5-.7) Test Criteria

<table>
<thead>
<tr>
<th>Test Equipment</th>
<th>202A Sec. 4.2(b)</th>
<th>Test Description</th>
<th>Test Criteria</th>
</tr>
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<tr>
<td>165 mm, 6.8 kg Headform using Linear Impactor Propulsion System</td>
<td>(5) Energy Absorption</td>
<td>Impact the front surface of the head restraint at 24.1 kph (within impact zone)</td>
<td>3 msec Clip&lt;80 g’s.</td>
</tr>
<tr>
<td>Vertical Load Test using 165/152 mm Cylindrical Headform</td>
<td>(6) Height Retention</td>
<td>Apply 500 N in the vertical direction.</td>
<td>Initial displacement &lt; 25 mm to achieve 50 N. Change in position at 50 N must be &lt; 13 mm. Must hold 500 N for 5 seconds.</td>
</tr>
<tr>
<td>Head Restraint Rearward Moment Test System</td>
<td>(7a) Displacement</td>
<td>Simultaneous loads applied to seat back and head restraint.</td>
<td>Headform displ.&lt;102 mm at 373 Nm about H-Point.</td>
</tr>
<tr>
<td></td>
<td>(7a) Backset Retention</td>
<td></td>
<td>Initial displacement &lt; 25 mm to achieve 37 Nm. Head form position change &lt;13 mm at 37 Nm.</td>
</tr>
<tr>
<td></td>
<td>(7b) Strength</td>
<td></td>
<td>Reach and sustain 890 N for five seconds.</td>
</tr>
</tbody>
</table>
S4.2.1-.4 Dimensional Criteria uses the ICBC HRMD, and the SAE J826 H-Point Machine

- H-Point
  - (1a) Minimum Height – Front H/R
  - (1b) Minimum Height – O/B H/R
  - (2) Width
  - (3) Backset
  - (4) Gaps
H-Point Test Procedure (Seats without independent cushions):

- Set the fore/aft track and vertical adjusters to the position that will result in the highest H-Point with respect to the seat back. If there is no effect on H-Point height, then place in full down/full rearward.
- Set the lumbar to full off position.
- Set the seat back recliner to achieve the design torso angle provided by the manufacturer.
H-Point Test Procedure (Seats with independent cushions):
• Set the fore/aft track and vertical adjusters to the position that will result in the highest H-Point with respect to the seat back.
• Set the lumbar to full off position.
• Set the seat back recliner to achieve the design torso angle provided by the manufacturer.
• When in vehicle, interior components may limit the vertical adjustment.
• Install the H-Point machine into the seat according to the SAE J826 procedure.
• Make sure the leg and thigh lengths are set according to FMVSS 208.
FMVSS 202a S4.2 STATIC OPTION

S4.2.1/5.2.1 Height

Manufacturer Design Torso Angle

HEIGHT ≥ 750 mm

H-POINT

HEIGHT

TORSO REFERENCE LINE

FRONT SEAT ADJUSTABLE HEAD RESTRAINT IN LOWEST POSITION
• Height is measured from the H-Point to the top of the head restraint normal to the torso angle

• All adjustment positions, including non-locking, are evaluated unless it is a non-use position.

• Front O/B Seats: Height ≥ 800 mm at 1 adjustment position
• All O/B Seats: Height ≥ 750 mm at all adjustment positions

• For some vehicles there are exemptions to the minimum height requirement depending on the vehicle roof line (minimum limit is 700 mm).
Using the height measuring device off of the centerline of the h-point machine…
Measure and mark a point 65 ± 3mm below the bottom edge of the height measuring device along the measured torso angle.
FMVSS 202a S4.2 STATIC OPTION

S4.2.2/5.2.2 Width

Measure the width of the head restraint at the point previously marked on the head restraint at the design torso angle. The head restraint width must be greater than 170 mm along this line.

For front O/B seats - if a center belted occupant exists then the width must be greater than 254 mm.
S4.2.3/5.2.3 - Backset

- New requirement for FMVSS 202a (I1WPG has a similar measurement).
- Remove 4 torso weights and install 2 HRMD weights and the HRMD.
- Make sure the torso angle does not change from the initial position.
- Make sure the HRMD is level.
- Backset applies only to front O/B H/R at any height between 750-800 mm.

- Requirement for backset < 55 mm.
FMVSS 202a S4.2 STATIC OPTION

- New requirement for FMVSS 202a (similar measurements found in ECE-17).
- Any gap over 540 mm above the H-Point and within 85 mm of the vertical centerline is evaluated.
- If the front seat has a center occupant then evaluate the gaps within 127 mm of the vertical centerline.
• Use the sphere to measure the gap for all H/R types.
• Maintain a maximum 5 N force limit.

• For an adjustable H/R only, the 25 mm cylinder may be used.
• Maintain a maximum 5 N force limit.
Gaps Between S/B and H/R

Gaps within H/R

540 mm above the H-Point

Gaps can be measured anywhere between the two boundary lines.
FMVSS 202a S4.2 STATIC OPTION

- 165 mm headform
- 6.8 kg moving mass (15 lbs)
- 24.1 km/h impact velocity
- Impact zone
- Any H/R adjustment position
- Linear Impactor
- Uniaxial acceleration
- 3 msec Clip under 80 g’s

S4.2.5/5.2.5 – Energy Absorption
The impact point is chosen anywhere inside the impact zone and at any H/R adjustment position.

Determine worst case impact point.
**FMVSS 202a S4.2 STATIC OPTION**

S4.2.6 - Height Retention

- Load point at “top” of H/R and centered on the H/R proper.
- Two required H/R test positions:
  - Front Seats: Full up and closest to 800 mm
  - Rear Seats: Full up and closest to 750 mm
- Vertical test direction.

- Three test requirements:
  - Initial displacement (D1) < 25 mm at 50 N
  - 500 N maximum load (hold for 5 sec.)
  - Remove load for 120 sec. prior to 50 N re-load (D3-D1) < 13 mm
S4.2.6–Height Retention

**S5.2.6 Headform Loading Profile**

- **Req’1 at 50 N**
- **Req’2 at 500 N**
- **Req’3 at 50 N**

**Force (N)**
- 0
- 100
- 200
- 300
- 400
- 500
- 600

**Time (sec)**
- 0
- 100
- 200
- 300
- 400
- 500

Additional note: Addition of a 2 minute load removal to allow recovery time for the head restraint.
FMVSS 202a S4.2 STATIC OPTION

S4.2.6–Height Retention

Max: 502.8 N @ 21.8 mm/Min: -24.9 N @ -3.6 mm

Retention Disp = 2.5 mm

D1 = 3.9 mm @ 50.0 N

Hold Time @ 500 N = > 5.0 seconds

ES7250-B: LH Head Force (N) vs. LH Head Disp. (mm)
Seat setup to average H-Point from dimensional evaluation.

Torso moment of 373 N-m applied initially through the backpan.

Maintain the backpan position during H/R loading.

Four test requirements:
- Initial displacement (D1-D0) < 25 mm
- Displacement (D2) < 102 mm
- Backset Retention (D3-D1) < 13 mm.
- Must hold 890 N for 5 seconds.
S4.2.7/5.2.7 a/b – Backset Retention, Displacement and Strength

This is the initial starting position (D0). D1 and D3 are measured relative to this initial position.

- D1 is measured at the initial 37 Nm moment.
- D3 is measured at the 2nd 37 Nm moment (after 120 sec unloading).
- D3 – D1 < 13 mm.
Displaced torso reference line (DTRL).
D2 is measured relative to this line.
This line represents 0 mm.
D2 requirement < 102 mm past the DTRL.
If 373 Nm is reached prior to crossing this line, then D2 will be negative.
The Part A test (Torso Loading) begins at 37 Nm moment.

Part A is complete when the applied moment reaches 373 Nm. This position is maintained throughout the H/ R loading (Part B).
S5.2.7 Headform Loading Profile

- Req’t 1 at 37 Nm
- Req’t 2 at 373 Nm
- Req’t 3 at 37 Nm
- Req’t 4 at 890 N

Addition of a 2 minute load removal to allow recovery time for the head restraint.
FMVSS 202a S4.2 STATIC OPTION

S4.2.7/5.2.7

Max: 831.1 N.m @ 15.3 mm/Min: -6.8 N.m @ -101.1 mm

D2 = -48.2 mm @ 373.0 +/- 7.5 Nm

Retention Disp = 5.0 mm
D1 = 8.8 mm @ 373 +/- 0.7 Nm

Hold Time @ 373 Nm > 5.0 seconds

RH Head Moment (N.m) vs. RH Head Disp. (mm)
Critical Items to Consider for the S4.2 Static Test Option:

- Consider the vehicle environment in the setup and/or fixture if not using a full vehicle.
- The NHTSA will use a full vehicle for compliance testing. However, development testing is typically been conducted on rigid fixture.
- In order to complete a full S4.2 static test series, 2 seats are required per occupant position.
- The S4.2.7 backset retention, displacement and strength test and the S4.2.5 energy absorption test should not be conducted on the same seat.
FMVSS 202a S4.3
DYNAMIC OPTION
S4.3 – Dynamic Sled Criteria

- Following the S5.3 demonstration procedure, conduct an occupied sled test using a half-sine pulse (8-9.6 g’s, 80-96 msec, 17.3 +/- 0.6 kph).
- 50th% male ATD at any outboard seating position equipped with a head restraint.
- Head restraint at mid up position and any backset.
- Rearward angular rotation between the head relative to the torso of the ATD to be less than 12°.
- HIC$_{15}$ less than 500.
- Meet lateral width dimensional criteria (S4.2.2).
S4.3 Dynamic Sled Procedure

1. Measure the test seat to determine H-point, backset, and H/R width (≥170mm).

2. Position the dummy in the measured seat according to measured H-point, pelvis angle, and then level the head.

3. Run the dynamic sled test and calculate the test criteria values using the ATD instrumentation.

4. Requirements are HIC < 500 and Relative Angular Rotation < 12°.
Determine the proper floor height and toe board location for the seat.
Adjust the lumbar to the most posterior position.
FMVSS 202a S4.3 DYNAMIC OPTION

Move tracks to the forward-most position and mark that position.

Move tracks to the rearmost position and mark the position.
FMVSS 202a S4.3 DYNAMIC OPTION

Measure the distance between the forward-most and rearmost marks to determine the true mid position.

Mark and set the tracks to the mid position.

*** If a locking position does not exist at the true mid position, set the tracks to the locking position rearward of but closest to true mid.
If the seat cushion adjusts independently of the seat back...

Position the cushion such that the highest H-point is achieved relative to the seat back.
***If the seat cushion does not adjust independently of the seat back, set the adjustment to the full down position.
Place a piece of muslin cotton cloth over the seat.

Tuck the cloth in a sufficient amount to prevent hammocking.
Place the H-point machine so that it is centered and level in the seat.
Attach the T-bar so the thigh segment is adjusted to 15.8 inches and the knees are spaced 10 inches apart.

Position the lower legs at 16.3 inches.
Position the feet so the heel is resting on the foot plate and the feet are flat on the angled toe board.
Place the **leg** and **thigh** weights onto the H-point machine.
With the back pan tilted forward, use the plunger to apply a 10 kg (22 lb) load twice at the intersection of the hip angle and T-bar housing.

For the remainder of the procedure, restrain the H-point machine at the T-bar to prevent any forward movement.
After returning the back pan to the seat back, add the two buttock weights..
and the eight torso weights…
FMVSS 202a S4.3 DYNAMIC OPTION

alternating left to right
Tilting the back pan forward until the stop is contacted, rock the H-Point machine over a 10° arch (5° to each side of the vertical centerline) for three complete cycles. Level the H-point machine after the third cycle.
Alternately lift each foot off the floor the minimum necessary amount until no additional forward movement is obtained.
After returning the back pan to the seat back, apply sufficient force perpendicular to the back angle bar to increase the hip angle up to 3° and release.
FMVSS 202a S4.3 DYNAMIC OPTION

Verify if the torso angle is $25^\circ \pm 1^\circ$.

If the torso angle does not fall within the range, the H-point machine must be removed, the seat back angle adjusted to achieve $25^\circ$, and the procedure must be repeated.

If the torso angle falls within range, measure and record the torso angle and seat back angle. Mark the recliner at this position as a visual reference of the seat back position if it should move.
Using the height measuring device off of the centerline of the H-point machine…
Measure and mark a point 65 ± 3 mm below the bottom edge of the height measuring device.
FMVSS 202a S4.3 DYNAMIC OPTION

Measure the width of the head restraint at the point previously marked on the head restraint at a 25° angle. The head restraint width must be greater than 170 mm along this line.
Measure and document the H-point from both sides of the H-point machine.

The target H-Point for the ATD in test position is the average of the x coordinates of the H-point machine and the average of the z coordinates -6mm.
Remove four torso weights (2 from each side) from the H-point machine and install two large HRMD torso weights (1 on each side).
While bracing the H-point machine to prevent movement, install the HRMD and level it.
Measure the head restraint height and backset at the full up and full down positions.

Mid position (test position) is the average of the full up and full down height. If a locking position does not exist at mid height, the test position is the next locking position down from mid height.
FMVSS 202a S4.3 DYNAMIC OPTION

Measure the height and backset at test position, mark the rods as a visual reference in case the head restraint is moved out of position.
*** For head restraints with horizontal adjustment, set the horizontal adjustment to the most posterior position.
Place, centered in the seat, a Hybrid III 50th percentile male ATD instrumented with head accelerometers (XYZ) and DTS angular rate sensors in the head and torso.

Position the ATD’s feet flat on the toe board with the feet resting flat on the foot plate. Position the knees and ankles at 10.6 inches apart measured from the outboard knee clevis flange surface.
Verify that the ATD’s pelvis angle is at 22.5° ± 2.5° and record the measured pelvis angle
Verify the ATD’s head is level at 0° in both the lateral and longitudinal direction within 0.5° and record these measurements.
FMVSS 202a S4.3 DYNAMIC OPTION

Measure both the inboard and outboard H-point and verify that it is ±12 mm of the target established by the H-point machine.
FMVSS 202a S4.3 DYNAMIC OPTION

Measure and record the ATD height relative to the head restraint, as well as the ATD backset.
Measure and record the ATD’s heel point
Restrain the ATD using production webbing for compliance testing or a standard three point harness if production webbing is not available.
FMVSS 202a S4.3 DYNAMIC OPTION

S4.3 Dynamic Sled Pulse

Requirements
• Acceleration
  • 8.16g – 9.58g
• Velocity
  • 10.4mph – 11.1mph
• Duration
  • 84ms – 92ms
Limit the rearward angular rotation between the head relative to the torso to less then 12°.
FMVSS 202a S4.3 DYNAMIC OPTION

Rotation Results

Maximum Relative Rotation (deg) = -15.81
Maximum Head Rotation (deg) = -28.10
Maximum Torso Rotation (deg) = -17.45
FMVSS 202a S4.3 DYNAMIC OPTION

Resultant Acceleration

\[ \text{HIC} = \left[ \frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} \text{adt} \right]^{2.5} (t_2 - t_1) \]

HIC\textsubscript{15} = 17.07

HIC = 17.07
Critical Items to Consider for the Dynamic Test:

- Consider the vehicle environment in the setup and/or fixture if not using a full vehicle.
- The NHTSA will use a full vehicle for compliance testing. However, development testing is typically been conducted on rigid fixtures.
- Compare the measured H-point to the ATD position.
- In general, minimizing the pre-test backset generally results in better rotation values but this does not apply to all head restraints, especially some active head restraints.
- The overall design of the seat (i.e., manual vs. power) has an affect on the performance of the head restraint.
CONCLUSIONS
CONCLUSIONS

• The general trend among OEMs is that both options are considered for front seats and the static option is chosen for rear seats.

• New head restraint designs (forward tilt; larger surface area, etc.) are sufficient for compliance but consumer complaints regarding comfort and styling are forcing re-designs.

• The release of both the updated static OVSC procedure as well as the first release of the dynamic OVSC procedure is anticipated in 2010.
CONCLUSIONS

• Head restraint standards and regulations will continue to evolve globally.
• IIHS/IWPG will continue to influence new designs.
• With the exception of backset, the S4.2 dimensional measurements are very similar to the ECE-17 regulation.
• Future studies may be needed to evaluate the overall effectiveness of new head restraint designs with respect to affording additional protection to occupants, especially whiplash.
CONCLUSIONS

- What consequences have surfaced due to new H/R technology?
  - Pose a challenge to comfort and styling
  - Incidental deployment of active systems
  - Replacement cost and consideration after low speed crashes
  - Increased weight affects CG
  - Active head restraint technology may incorporate additional sensor systems
  - After-market products such as DVD entertainment systems need separate compliance testing.
QUESTION AND ANSWER
Thank you for participating!

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