TR-2
PPI PVC Range Composition Listing of Qualified Ingredients
3/19/2013

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Foreword

This technical report was developed and published with the technical help and financial support of the members of the PPI (Plastics Pipe Institute). The members have shown their interest in quality products by assisting independent standards-making and user organizations in the development of standards, and also by developing reports on an industry-wide basis to help engineers, code officials, specifying groups, and users.

PPI's PVC range composition and all applicable policies are included in this technical report. This technical report lists of each of the ingredients that have been accepted by the Hydrostatic Stress Board (HSB) by its commercial designation as qualified for use in PPI's PVC Range Composition. Requirements for acceptance are covered by applicable PPI policy or, in cases for which there is no applicable policy, the HSB may determine these requirements through a "Special Case" consideration. The listings included in this report also show allowable use levels for each ingredient and any other applicable limitation.

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PPI intends to revise this technical report annually, in response to comments and suggestions from users of the report. Please send suggestions of improvements to PPI. This report, as well as other publications, is available for download from PPI on the website www.plasticpipe.org.

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I. Definitions Specific to TR-2

Vinyl Plastics – Compositions of polymers and ingredients that are based on polymers of vinyl chloride, or copolymers of vinyl chloride with other monomers, the vinyl chloride being in the greatest amount by mass. Within the context of TR-2 the term vinyl is limited to compositions of polyvinyl chloride (PVC).

Ingredient – Any chemical, mineral, polymer or other ingredient that has been added to a vinyl composition for the purpose of imparting certain desired processing or product performance properties.

Pre-qualified Ingredient – Any chemical, mineral, polymer, etc. having properties meeting the applicable requirements as set forth in Section III Part B.

Functionally Equivalent Ingredient – Any chemical, mineral, polymer, etc. not having properties meeting the applicable requirements as set forth in Section III Part B and shown to function in an equivalent manner through testing.

Combination Ingredient Package – A set ratio of a pre-blended combination of pre-qualified ingredients. As a service to formulators of PVC pipe compounders, some suppliers of ingredients make available "packages" of pre-blended combinations of Pre-qualified Ingredients provided: 1) each of its individual ingredients is qualified for such use; and 2) the net amount of each individual ingredient that is introduced into the composition, both through the "package" and by direct addition, is in compliance with the composition requirements for that ingredient. It is the responsibility of the formulator to make sure that the PPI PVC range composition is always prepared in accordance with the currently listed composition.

Functional Equivalent Ingredient Package – A set ratio of a pre-blended combination of ingredients containing an ingredient/ingredients that is not pre-qualified. This package will be accepted for listing upon completion of testing demonstrating that its use in PPI's PVC Range Composition continues to yield a PVC compound that complies with the minimum property requirements for cell class 12454, in accordance with ASTM D1784, and that qualifies for a 4,000 psi HDB, for water, for 73.4°F, in accordance with ASTM D2837. There is no standard protocol, or policy for effecting this demonstration. Minimum data requirements are established by the HSB for each case, depending on the nature of the ingredients, and the information already available. Those seeking to qualify these kinds of combinations of ingredients should make a "Special Case" request of the Chairman of the HSB.

PPI PVC Range Composition – A PVC composition, classified as PVC 1120, Class 12454 in accordance with applicable ASTM requirements, that carries a PPI recommended hydrostatic design basis (HDB) of 4,000 psi (27.58 MPa) for water for 73.4°F (23°C), with such basis having been established in accordance with requirements stated in PPI Technical Reports TR-2 and TR-3. This composition is maintained by the HSB of PPI and is made available for use by the general public.

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Privately held PVC Composition – A privately held PVC composition that carries a PPI recommended hydrostatic design basis (HDB) that has been established based on the requirements of PPI Technical Reports TR-2 and TR-3. This private composition is maintained by a specific company or organization and is not made available by PPI to the general public.

Standard Grade (S) - A PPI HSB recommended rating that is valid for a five-year period, given to those materials that comply with the full data requirements of TR-2 and TR-3.

Experimental Grade (E) - A PPI HSB recommended rating that is valid for a limited duration, given to those materials covered by data that do not yet comply with the full requirements of the Standard Grade, but satisfy the applicable minimum preliminary data requirements that are detailed in TR-2 and TR-3. The owner of an experimental listing must understand there is a potential risk in commercial sale of an experimental ingredient in case it does not meet all theTR-2 requirements.

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II. Introduction

It was recognized early in the evolution of the thermoplastics pipe industry that in consequence of its viscoelastic nature, the fracture strength of a thermoplastic polymer is significantly influenced – for any given set of conditions of temperature and environment – by duration of loading. The longer a load is sustained; the lower is the fracture strength. It was also recognized that the long-term strength of a thermoplastics composition is not only determined by the primary ingredient, the base polymer, but can also be profoundly influenced by the nature and quantity of ingredients – such as property modifiers, processing aids, stabilizers, and colorants – that are used to enhance performance and facilitate processing, and to give product identification. But in those early days there existed no standard method by which reliable design stresses could be established for thermoplastic compositions intended for pressure pipe. All too often, design stresses were based on results of relatively short-term loading with *safety factors* that – based on experience, educated guess, limited experience, or other rationale – were said to adequately compensate for the reduction in long-term strength that characteristically occurs with all plastics when subjected to prolonged loading. Unfortunately, this approach was not only inconsistent from material to material, but oftentimes it was unreliable. The long-term strength of some materials was overestimated, while that of others was underestimated.

To remedy this situation, the Thermoplastics Pipe Division (subsequently named the Plastics Pipe Institute) of the Society of the Plastics Industry established in November 1958 the Working Stress Subcommittee, the predecessor to the Hydrostatic Stress Board (HSB), consisting of technical persons well versed in the state-of-the-art of the evaluation and forecast of the long-term strength of plastics. Two and half years later, in April 1961, this group agreed on a uniform Tentative Method for Estimating Long-Term Hydrostatic Strength and Hydrostatic Design Stress of Thermoplastic Pipe; and in July 1963, it issued its first hydrostatic design stress recommendations for compositions for which data had been submitted in accordance with this method.

A frequent challenge to the HSB was the evolutionary nature of the industry, particularly in the case of PVC pipe compositions. At first, each PVC composition was a fixed and very specific composition, with the use level and identity of each ingredient spelled out. The ingredient identification would often consist of a manufacturer's trade designation. In search of more effective and less costly sources of ingredients, companies holding listings for PVC compositions would often qualify alternative sources of a certain ingredient. To demonstrate qualification a company had to submit to the HSB extensive long-term data that showed the proposed change would not compromise a listed composition's long-term strength. From the knowledge learned by this work, policies were developed whereby a newly proposed ingredient, for example, a calcium carbonate – can qualify for that purpose provided it is demonstrated that its physical and chemical properties comply to requirements that have been established for that class of ingredient based on results of industry wide testing. These policies provided for pre-qualification of ingredients that greatly facilitated the process of determining equivalence.

Later on, during the seventies, the concept of "PVC range compositions" was introduced. As new and improved extrusion technology began to be used, it was discovered that fine-tuning the quantity of certain ingredients – particularly, so called "internal" and "external" lubricants – would greatly benefit production rate and product quality. To avoid the impracticality of having to qualify each composition variation, industry expanded their fixed content recipes into range compositions, whereby the allowable content of certain ingredients was defined not by a

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fixed amount but rather, by a minimum/maximum range. The acceptable ranges of ingredient content had also to be established by long-term data documentation.

To make it possible to use resins and other ingredients from different suppliers, extruders of PVC pipe had to qualify a number of "different" range PVC compositions – each provided by a different resin supplier – which in fact were often times quite the same except for source of resin, or some other key ingredient. For a manufacturer of a new ingredient, or of an alternative to an existing ingredient, having to qualify his product for inclusion in the many private PVC range compositions that then abounded was a costly and time consuming process. In recognition of this situation, the HSB proposed in 1983 to establish a single, generic and public PVC range composition which then included all PVC resins and ingredients which had been qualified in privately held compositions of the same kind. To accomplish this required the cooperation of all major holders of PVC compositions, including their willingness to share with the HSB their confidential recipes. This cooperation was obtained, the compositions of the many stress-rated compositions were compared, and a single, generic, state-of-the-art composition was established which allowed a wide choice in PVC resins and in ingredients.

The HSB next worked on defining the policies and procedures for qualifying new ingredients. In 1985 the PPI PVC range composition and related policies were agreed upon and are published in this report. Since that time many new alternate ingredients have been qualified for use in this composition.

The policies and procedures in this Technical Report are intended to cover ingredient listings for most PVC piping applications. PPI recognizes there may be unusual cases, issues or circumstances that are not covered in TR-2, and that may justify an exception to the standard policies. To allow manufacturers an opportunity to have their ingredient(s) listed by PPI when this occurs, the HSB has provided a "Special Case" system. The manufacturer may present its "Case" to the HSB at one of their two annual meetings, usually in February and August, using the approved "Special Case" form in TR-3. All information provided to HSB in these special cases will be made available for review only by HSB members and PPI staff, and will be held by them in strict confidence, in accordance with PPI's written confidentiality procedures (available from the HSB Chairman). There is a PPI fee for each special case. You must contact the HSB Chairman well in advance of each meeting to arrange for your special case. A completed HSB submission form **must** be received at least two (2) weeks prior to the HSB meeting to permit HSB consideration at that meeting.

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III. PPI PVC Range Composition

The HSB has classified all ingredients in the PPI PVC range composition into four classes. Two classes cover **pre-qualified ingredients (Part A)** and the other two cover **functional equivalents (Part B)**, as follows:

- Ingredients that are **pre-qualified** for use in PPI's PVC Range Composition by the demonstration of the ingredient's compliance to chemical and physical property requirements of the applicable HSB policy;
- Packages (blends) of **pre-qualified** ingredients;
- Ingredients that although not meeting applicable pre-qualification requirements for that class of ingredient they exhibit an **equivalent function;**
- Packages (blends) of qualified ingredients, one or more of which is a **functional equivalent** to a pre-qualified ingredient.

In its continuing commitment to provide effective service to the industry, this TR-2 lists qualified ingredients in accordance with the above classification system.

Because the PPI PVC Range Composition has been established from a matrix of PPI listed range compositions – each of which has a 4,000 psi hydrostatic design basis at 73.4°F that has been established through extensive stress-rupture testing – a company may obtain a *dependent* listing under this composition without having to submit any additional stress-rupture data. However, a company obtaining a dependent listing under PPI's PVC Range Composition must agree to formulate, and only use the materials as prescribed by Part A. Information on how a dependent listing may be obtained is given in Appendix A.

Part A. Pre-qualified Ingredients Exempted From Stress-Rupture Testing

An individual or combination ingredient that meets the allowable content range in Table 1 and the physical property requirements of Part A is a pre-qualified ingredient and is exempt from stress rupture testing for qualification. An ingredient manufacturer may still elect to publish this pre-qualified ingredient in the appropriate table in TR-2.

A PVC composition that complies with the minimum property requirements of cell class 12454 according to ASTM D 1784 and that satisfies the limitations of the PVC range formulation given in Table I, qualifies for a recommended hydrostatic design basis (HDB) of 4,000 psi at 73°F (23°C) without the need to submit the stress-rupture data. A manufacturer wishing to register this PVC range composition for use in his plant should apply to the Chairman of PPI's HSB and identify the manufacturer's commercial designation for this composition. These PVC compositions are dependent on the PPI PVC range composition and are published in PPI TR-4.

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TABLE I

PPI PVC RANGE COMPOSITION FOR LISTING AT 73°F (23°C)

Ingredient	Qualification Requirements	Allowable Content Range (in parts per hundred parts of resin)
PVC Resin	Compliance to B.1 and Listing by PPI	100
Heat Stabilizer	Compliance to B.2 and Listing by PPI	0.3 - 1.0
Calcium Stearate	Compliance to A.2	0.4 - 1.5
Paraffin Wax	Compliance to A.3	0.6 -1.5
Polyethylene Wax	Compliance to A.4	0.0 - 0.3
Titanium Dioxide	Compliance to A.5	0.5 - 3.0
Calcium Carbonate	Compliance to A.6	0.0 - 5.0
Process Aid	Compliance to B.2 and Listing by PPI	0.0 -2.0
Colorant	Compliance to B.2 and Listing by PPI, or compliance to TR-3 Part D.1	See Table 9
Combination and Functional Equivalent	Listing By PPI	

NOTE: See TR-2, Section IV for listing of Prequalified and Functionally Equivalent Ingredients

The pipe manufacturer is encouraged to perform some stress-rupture testing on any combination of ingredients that is new to him to ensure that the anticipated strength is realized under the selected processing conditions. One of the best means to check for proper processing is by use of either the Accelerated Regression Test (ASTM D 2241) or other long-term stress-rupture data generated in accordance with ASTM D 1598 and analyzed by the method of least squares as described in ASTM D 2837.

Part A.1 PVC Resin

This policy only applies to suspension grades of PVC resins.

There are no pre-qualified PVC resins for the PPI PVC Generic Range Formulation. All PVC resins must be qualified according to Part B.

PVC Resin made in a new plant – For equivalent PVC resin that is currently listed in TR-2 that is made in a new plant, a provisional listing will be granted based on manufacturer's data supporting equality of the resin through chemical and physical property analysis. E-2 level hydrostatic data is required for a standard grade listing.

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Part A.2 Calcium Stearate

The following guidelines are not to be considered as specifications or standards to indicate the requirements for calcium stearates, nor is it intended that they describe all the commercial calcium stearates that are suitable for use in polyvinyl chloride (PVC) plastic pipe compounds. The intent is only to give guidelines for alternative use of members of a group of commercial calcium stearates that are apparently chemically identical and that have been found by physio-chemical analysis, by engineering pipe testing, and by use of pipe in the field to be sufficiently similar in nature to produce pipe and fittings that are basically the same in properties and performance. Consideration has been given to physio-chemical analysis of the calcium stearates, long-term hydrostatic pressure testing of pipe, and requirements of the applicable pipe standards.

Commercial calcium stearates may be substituted one for another in polyvinyl chloride (PVC) plastic pipe and fitting compounds without additional long-term pipe testing provided (1) the substitution is for the same amount, (2) the substitution in the compound is 1.5 parts or less per hundred parts of resin and (3) the properties fall within the ranges given below:

Property (See Note 1)	**Requirements**
Melting Point, °F (°C)	293-329 (145-165)
Chlorides, as chloride ion, %, max	0.3
Free fatty acid, %, max	1.0
Acid number (See Note 2)	200 +/- 15
Iodine value, max (See Note 2)	5.0
Volatile content, at 221 °F (105 °C), %, max	3.5
Ash, as CaO, at 1832 °F (1000 °C)	9.00 – 12.0
Iron, ppm, max	100
Color	White to off-white
Particle Size	At least 95% through U.S. Standard 20 mesh

NOTE 1: The test methods shall be those commonly used in the calcium stearate industry.
NOTE 2: Acid number and iodine value apply to the stearic acid raw material.

Calcium stearates not meeting these guidelines may be evaluated as a functional equivalent in accordance with the policies and procedures in Part B of TR-2. When sufficient data, background, and successful usage, both in production and service, have been developed with other calcium stearates, they may be considered for inclusion in a new group under these guidelines.

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Part A.3 Paraffinic Hydrocarbon Wax

The following guidelines are not to be considered as specifications or standards to indicate the requirements for hydrocarbon waxes, nor is it intended that they describe all the commercial hydrocarbon waxes that are suitable for use in polyvinyl chloride plastic (PVC) pipe compounds. The intent is only to give guidelines for the alternate use of members of a group of commercial paraffinic hydrocarbon waxes that have been found by physio-chemical analysis, by engineering pipe testing, and by use of pipe in the field to be sufficiently similar in properties and performance. Consideration has been given to physio-chemical analysis of the hydrocarbon waxes, long-term hydrostatic pressure testing of pipe, and requirements of the applicable standards (See Note 1).

Commercial paraffinic hydrocarbon waxes may be substituted one for another in polyvinyl chloride (PVC) plastic pipe and fitting compounds without additional long-term pipe testing provided (1) the substitution is for the same amount, (2) the substitution in the compound is 1.5 parts or less per hundred parts of resin, (3) the particle size is approximately the same and (4) the properties fall within the ranges given below:

PROPERTY	TEST METHOD (See Note 2)	REQUIREMENT
Chemical Type		*Hydrocarbon wax
Congealing Point,°F (°C)	ASTM D938	149 – 169 (65 – 76)
Viscosity at 210 °F	ASTM D445	5.5 – 7.5 cSt
Kinematic Carbon Number	ASTM D5442	Min 80% C26 – C50
Distribution of		<20% C26 and below
Normal Hydrocarbons		<10% above C50
		Zero
above C85		
Non-normal paraffin	ASTM D5442	10 – 50% Content
Needle Penetration (77°F)	ASTM D1321	10 – 18
Oil Content	ASTM D721	1% max
Flash point, °F (°C)	ASTM D92	446 (230)
Color (Saybolt)	ASTM D156	+10 min
Acid Number	ASTM D1386	0.5 max
Density, g/cm3	ASTM D792	0.915 – 0.940
Physical Appearance		Small uniform flake
		Prill or powder**

*Hydrocarbon waxes containing linear and branched chains with carbon numbers from C20 to C60.

** This requirement is not applicable when the wax is added as a liquid.

NOTE 1: Hydrocarbon waxes not meeting these guidelines may be evaluated as a functional equivalent in accordance with the policies and procedures in Part B of TR-2. When sufficient data, background, and successful usage, both in production and service, have been developed with other hydrocarbon waxes, they may be considered for inclusion in a new group under these guidelines.

NOTE 2: The test methods not prescribed shall be those currently used in the industry.

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Part A.4 Polyethylene Wax

The following guidelines are not to be considered as specifications or standards to indicate the requirements for polyethylene waxes, nor is it intended that they describe all the commercial polyethylene waxes that are suitable for use in polyvinyl chloride (PVC) plastic pipe compounds. The intent is only to give guidelines for alternative use of members of a group of commercial polyethylene waxes that are apparently identical and that have been found by physio-chemical analysis, by engineering pipe testing, and by the use of pipe in the field to be sufficiently similar in nature to produce pipe and fittings that are basically the same in properties and performance. Consideration has been given to physio-chemical analysis of the polyethylene waxes, long-term hydrostatic pressure testing of pipe, and requirements of the applicable standards (See Note 1).

Commercial polyethylene waxes may be substituted one for another in polyvinyl chloride (PVC) plastic pipe and fitting compounds without additional long-term pipe testing provided (1) the substitution is for the same amount, (2) the substitution in the compound is 0.3 parts or less per hundred parts of resin and (3) the properties fall within the ranges given below:

PROPERTY	ASTM TEST METHOD	REQUIREMENT
Gardner Color (Molten Wax)	D-1544	4 max
Flash point, minimum °F (°C)	D-92	500 (260) open cup 425 (218) closed cup
Ring and Ball Softening Point, °F (°C) Or Mettler Drop Point Test, °F (°C)	E-28 D3954	210 - 225 (99 - 107) 203 – 221 (95 – 105)
Thermosel Viscosity @ 283°F (140°C) cp	D-3236	70 - 400
Penetration Hardness	D-5	3 - 6
Acid Number, mg KOH/g	(1)	10 - 18

(1) The test method may be any that is commonly used by the industry such as Allied Chemical W-305-TW-1 or Eastman Chemical ECD 27-102.

NOTE 1: Polyethylene waxes not meeting these guidelines may be evaluated as a functional equivalent in accordance with the policies and procedures in Part B of TR-2. When sufficient data, background, and successful usage, both in production and service, have been developed with other polyethylene waxes, they may be considered for inclusion in a new group under these guidelines.

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Part A.5 Titanium Dioxide

The following guidelines are not to be considered as specifications or standards to indicate the requirements for titanium dioxides, nor is it intended that they describe all the commercial titanium dioxides that are suitable for use in polyvinyl chloride (PVC) plastic pipe compounds. The intent is only to give guidelines for alternative use of members of a group of commercial titanium dioxides that are apparently chemically identical and that have been found by physiochemical analysis, by engineering pipe testing, and by use of pipe in the field, to be sufficiently similar in nature to produce pipe and fittings that are basically the same in properties and performance. Consideration has been given to physiochemical analysis of the titanium dioxides, long-term hydrostatic pressure testing of pipe, and requirements of the applicable pipe standards. (See Note 1)

Commercial titanium dioxides may be substituted one for another in polyvinyl chloride (PVC) plastic pipe and fitting compounds without additional long-term pipe testing provided (1) the substitution is for the same amount, (2) the substitution in the compound is three parts or less per hundred parts of resin, and (3) they meet the following requirements:

Property (See Note 2):	
Crystal structure	Rutile
Particle size	
Average, microns	0.10 - 0.35
Retained on 325 mesh screen, %, max	0.20
Titanium dioxide content, %, min	92.00
Chemical modification	alumina and/or silica
Carbon content, at 1652 °F (900 °C), %, max (burn and measure carbon dioxide)	0.30
Volatile content loss at 221 °F (105 °C), %, max	0.70
Specific gravity	4.0 - 4.3

NOTE 1: Titanium dioxides not meeting these guidelines may be evaluated as a functional equivalent in accordance with the policies and procedures in Part B of TR-2. When sufficient data, background and successful usage, both in production and service, have been developed with other titanium dioxides, they may be considered for inclusion in a new group under these guidelines.

NOTE 2: The test methods shall be those described in ASTM D 476, "Standard Specification for Titanium Dioxide Pigments."

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Part A.6 Calcium Carbonate

The following guidelines are not to be considered as specifications or standards to indicate the requirements for calcium carbonate, nor is it intended that they describe all the commercial calcium carbonates that are suitable for use in polyvinyl chloride (PVC) plastic pipe and fitting compounds. The intent is only to give guidelines for the alternative use of members of two groups of commercial calcium carbonates that are apparently chemically identical (within each group) and that have been found by physio-chemical analysis, by engineering pipe testing, and by use of pipe in the field to be sufficiently similar (within each group) in nature to produce pipe and fittings that are basically the same in properties and performance. Consideration has been given to physio-chemical analysis of the calcium carbonates, long-term hydrostatic pressure testing of pipe, and requirements of the applicable pipe standards.

These guidelines cover two separate groups of calcium carbonates, Group A in which the particles are not coated with another material and Group B in which the particles are coated with commercial calcium stearate and/or stearic acid. Substitutions may be made within a group but not from one group to the other (See Note 1).

Group A (uncoated particles)
Uncoated commercial calcium carbonates may be substituted one for another in polyvinyl chloride (PVC) plastic pipe and fitting compounds without additional long-term testing provided (1) the substitution is for the same amount, (2) the amount used in the compound is five parts or less per hundred parts of resin, and (3) the properties fall within the ranges given below:

PROPERTY (PMD Test Methods – See Appendix B)		REQUIREMENT
General Description		**Calcium carbonate (Uncoated particles)**
Chemical analysis		
	Calcium carbonate analysis, min	94.00%
	Iron, as ferric oxide, max	0.25%
	Silica, SiO_2, max.	1.25%
	Weight loss at 221 °F (105 °C), max	0.50%
Particle properties		
	Type	Microcrystalline
	Size, micron, range	0.02 - 15.00
	Size, micron, mean	0.05 - 3.50
Other properties		
	Density, g/cm^3	2.65 - 2.71

Group B (Stearate coated)
Stearate coated commercial calcium carbonates may be substituted one for another in polyvinyl chloride (PVC) plastic pipe and fitting compounds without additional long-term pipe testing provided (1) the substitution is for the same amount, (2) the amount used in the compound is five parts or less per hundred of resin, and (3) the properties fall within the ranges given below:

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