

MIL-I-46182(MR)  
23 February 1982

## MILITARY SPECIFICATION

### IRON CASTINGS, SPHEROIDAL GRAPHITE (EXTRA TOUGH)

This specification is approved for use by the Army Materials and Mechanics Research Center, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

#### 1. SCOPE

1.1 Scope. This specification covers the requirements for heat-treated spheroidal graphite iron castings for use where a spheroidal graphite iron (also known as ductile iron and nodular iron) with maximum notch toughness is required (see 6.1).

#### 2. APPLICABLE DOCUMENTS

##### 2.1 Government documents.

2.1.1 Specifications and standards. Unless otherwise specified (see 6.2), the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitation, form a part of this specification to the extent specified herein.

#### SPECIFICATIONS

##### FEDERAL

PPP-B-585 - Boxes, Wood, Wirebound  
PPP-B-601 - Boxes, Wood, Cleated-Plywood  
PPP-B-621 - Boxes, Wood, Nailed and Lock-Corner  
PPP-C-843 - Cushioning Material, Cellulosic

##### MILITARY

MIL-P-116 - Preservation, Methods of  
MIL-B-121 - Barrier Material, Greaseproofed, Waterproofed, Flexible  
MIL-C-132 - Crate, Wood, Open; Maximum Capacity 2,500 Pounds  
MIL-L-10547 - Liners, Case, and Sheet, Overwrap; Water-Vaporproof or Waterproof, Flexible

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, US Army Materials and Mechanics Research Center, ATTN: DRXMR-SSS, Watertown, MA 02172 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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## STANDARDS

### FEDERAL

FED. TEST METHOD STD. NO. 151 - Metals, Test Methods

### MILITARY

- MIL-STD-10 - Surface Roughness, Waviness, and Lay
- MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes
- MIL-STD-129 - Marking for Shipment and Storage
- MIL-STD-130 - Identification Marking of US Military Property
- MIL-STD-271 - Nondestructive Testing Requirements for Metals
- MIL-STD-1188 - Commercial Packing of Supplies and Equipment

(Copies of specifications and standards required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DODISS and the supplement thereto, if applicable.

#### AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) Standards

- ASTM A327 - Impact Testing of Cast Irons
- ASTM E8 - Tension Testing of Metallic Materials
- ASTM E10 - Brinell Hardness of Metallic Materials, Test for
- ASTM E186 - Standard Reference Radiographs for Heavy-Walled (2 - 4-1/2 inch - 51-114 mm) Steel Castings
- ASTM E446 - Standard Reference Radiographs for Steel Castings Up to 2 inches (51 mm) In Thickness

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

## 3. REQUIREMENTS

3.1 Materials and process. Materials and process shall be such as to produce graphite iron castings conforming to the requirements of this specification.

3.2 Chemical composition. Castings shall conform to the chemical requirements shown in table I.

TABLE I. Chemical requirements

<u>Silicon</u> <u>(Maximum)</u>	<u>Phosphorus</u> <u>(Maximum)</u>	<u>Titanium</u> <u>(Maximum)</u>
2.2%	0.05%	0.05%

3.3 Mechanical properties. Unless otherwise specified in the contract or order (see 6.2), the mechanical properties of castings in the heat-treated condition shall be as shown in table II.

TABLE II. Mechanical properties

Tensile strength psi (minimum)	55,000
Yield strength 0.2 percent offset psi (minimum)	37,000
Elongation in 2 inches percent (minimum)	20.0
Charpy V-notch 20°F (-6.7°C) Impact strength ft-lbs (minimum)	10
Brinell Hardness (maximum)	175

3.4 Condition. Castings shall be furnished in the heat-treated condition (see 6.4). Heat treatment shall be such as to produce the mechanical properties of 3.3. Heat treatment shall be performed on the whole casting, never on a part only.

3.5 Soundness. Castings shall be of uniform quality, free from shrinks, cold shuts, cracks, harmful porosity, or other defects which would make the casting unsuitable for its intended use. Castings shall conform to the specified class of Radiographic Standards for Steel Castings, ASTM E446 and ASTM E186. The area or section of casting to be radiographed shall be specified in the drawing, contract or order.

3.6 Surface of castings. Castings shall be sandblasted, grit-blasted, or tumbled after heat treatment and shall be free from harmful defects.

3.7 Repairing of defects. Castings shall not be welded, plugged, or repaired in any manner without written permission from the procuring activity. Permission to repair defective castings, when granted by the procuring activity, shall not relieve the contractor of his responsibility for meeting all requirements of the drawings or the specification.



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**3.8 Dimensions.** The responsibility of furnishing castings that can be laid out and machined to the finished dimensions, within the specified tolerances as shown on the applicable drawings, shall rest with the contractor. Sufficient stock shall be allowed for shrinkage and, where required, for finishing; but castings of excessive size or weight shall not be furnished.

**3.9 Identification marking.** Castings covered by this specification shall be legibly and permanently marked in accordance with the requirements of MIL-STD-130 and the applicable drawings. Unless otherwise specified in the contract or order (see 6.2) and provided the size of casting is large enough to permit marking, each casting shall be identified with the pattern or part number by the use of raised numerals as shown on the applicable drawings. When the location of the marking is not shown on the drawings, the number shall be so located that it will not be obliterated or removed by any machining operation.

**3.9.1** Castings may be marked by impression stamping when specified on the applicable drawings. When the location of the impression marking is not shown on the drawings, the marking shall be located in such a manner as to minimize the danger of having a deleterious effect on the static or fatigue strength of the casting.

**3.10 Workmanship.** The workmanship shall be such as will produce acceptable castings in accordance with the requirements of this specification, the applicable drawings, and the contract or order. Runners, risers, fins, and other cast-on pieces shall be removed.

#### 4. QUALITY ASSURANCE PROVISIONS

**4.1 Responsibility for inspection.** Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

**4.2 Lot.** For purposes of sampling, a lot shall consist of all castings of the same pattern, or of some critical section size cast from the same inoculated ladle and heat-treated in the same furnace heat-treating charge, or if the heat-treating furnaces are provided with recording pyrometers, subjected to the same heat treatment; or if heat treated by a continuous process, subjected to the same heat treating cycle.

### 4.3 Sampling.

#### 4.3.1 Sampling for lot acceptance inspection.

4.3.1.1 For visual and dimensional examination. Sampling of castings for visual and dimensional inspection shall be in accordance with the provisions of MIL-STD-105, inspection level II, and acceptable quality level (AQL) 1.5 percent defective.

4.3.1.2 For soundness. Sampling of castings for soundness inspection shall be in accordance with the provisions of MIL-STD-105, inspection level II, and acceptable quality level (AQL) 1.0 percent defective.

4.3.1.3 For packaging, packing, and marking. A random sample of shipping containers for the inspection of 4.4.5 shall be selected by the Government inspector in accordance with the provision of MIL-STD-105, inspection level II, acceptable quality level (AQL) 4.0 percent defective.

#### 4.3.1.4 Sampling for tests.

4.3.1.4.1 For chemical analysis. One sample shall be obtained from each lot in accordance with Fed. Test Method Std. No. 151, Method III, for chemical analysis. Drillings for chemical analysis shall be taken from ladle samples, broken test specimens, or from castings selected by the Government inspector.

4.3.1.4.2 For tension and impact tests. At least two representative test specimens (one for tension tests and one for impact tests) shall be taken from each lot of castings. Test specimens shall be taken from separately cast "Y" blocks as shown in Figures 1 and 2. A separately cast 1-inch keel block as shown in Figure 3 may be substituted in lieu of the 1-inch "Y" block, at the option of the manufacturer. The size of coupon cast to represent the lot of castings shall be the style of block I, II or III (Figure 1) with "A" dimension closest to the thickest section of the casting. The test sample shall be heat treated with the lot of castings represented. Test samples shall be poured with approximately the last castings of the lot.

4.3.1.4.2.1 When agreed upon by the Government and the contractor, castings may be used as test samples. When castings are used for test samples, the same principles as to some of pouring shall be observed.

4.3.1.4.3 For hardness tests. Sampling of castings for hardness tests shall be in accordance with the provisions of MIL-STD-105, inspection level II, and acceptance quality level (AQL) 1.5 percent.

4.3.1.4.3.1 When agreed upon by the Government and the contractor, the test specimens selected for tension and impact tests may be used for hardness tests.

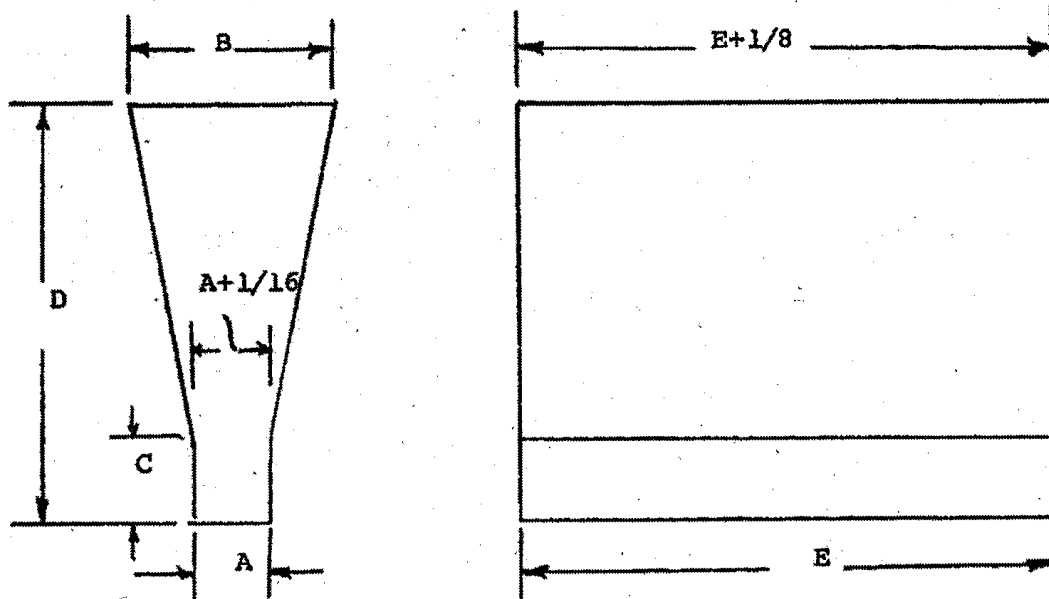
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**4.4 Lot acceptance inspection.**

**4.4.1 Visual and dimensional examination.** Sample castings selected in accordance with 4.3.1.1 shall be inspected to determine conformance to the dimensional requirements of 3.8, the identification marking of 3.9, and the workmanship requirements of 3.10.

**4.4.2 Soundness inspection.** Sample castings selected in accordance with 4.3.1.2 shall be subjected to magnetic particle inspection and radiographic inspection in accordance with the provisions of MIL-STD-271 to determine conformance to the soundness requirements of 3.5. The magnetic particle inspection shall be performed on castings with surface roughness not to exceed 250RHA as interpreted in accordance with MIL-STD-10.

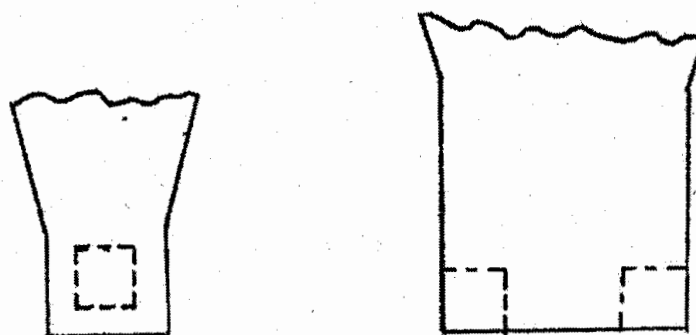
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Style of block	Dimensions of block				
	A (Inches)	B (Inches)	C (Inches)	D (Inches)	E (Inches)
I	1/2	1-5/8	3/4	5-3/8	6
II	1	2-1/8	1-1/2	4	6
III	3	3	2-5/8	5-3/8	6

FIGURE 1. "Y" block casting

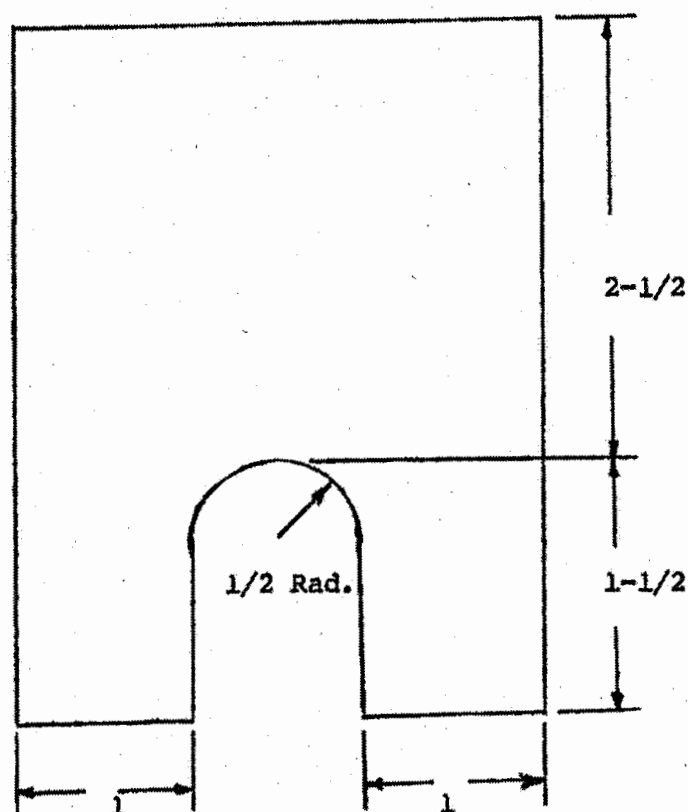
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Style "A" block

Style "B" block

FIGURE 2. Location of test specimens



NOTE: Length shall be 6 inches long.

FIGURE 3. Keel block casting



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4.4.3 Preservation, packaging, packing, and marking. The inspector shall ascertain that preservation, packaging, and packing of castings and marking of containers selected in accordance with 4.3.1.3 is in accordance with the requirements of this specification and the contract or order.

4.4.4 Place of inspection. Unless otherwise specified (see 6.2), inspection and tests shall be conducted at the place of manufacture.

#### 4.4.5 Tests.

4.4.5.1 Chemical composition. Unless otherwise specified, the samples selected in accordance with 4.3.1.4.1 shall be analyzed in accordance with either Method 111 or 112 of Fed. Test Method Std. No. 151 to determine conformance to the chemical requirements of 3.2.

4.4.5.2 Tension tests. Test specimens prepared and selected in accordance with 4.3.1.4.2 shall be tested in accordance with ASTM E8 for conformance to the tensile properties of 3.3.

4.4.5.2.1 Yield strength. Yield strength shall be determined by the offset method as described in ASTM E8. The limiting set shall be 0.2 percent (0.002 inch per inch of gage length).

4.4.5.3 Impact tests. Test specimens selected in accordance with 4.3.1.4.2 shall be machined to the dimensions of a V-notched Charpy specimen and tested at 20°F. (-6.7°C) in accordance with ASTM A327. Three Charpy V-notched specimens shall be tested and the average of the impact strength obtained on these specimens shall be used to determine compliance with requirements of 3.3.

4.4.5.4 Hardness tests. Test specimens selected in accordance with 4.3.1.4.3 shall be tested in accordance with ASTM E10 for conformance to the hardness requirements of 3.3.

4.5 Rejection and retest. If a test specimen fails to conform to the requirements of this specification, the lot represented by the specimen shall be rejected. If the failure is due to improper heat treatment, the lot may be reheat-treated and resubmitted. Only one such reheat treatment shall be permitted. Retests shall be permitted in accordance with the procedures set forth in the applicable sections of Fed. Test Method Std. No. 151.

## 5. PACKAGING

5.1 General requirements. Castings shall be prepared for shipment in accordance with Level A, B or C, as specified in the contract or order (see 6.2).

5.1.1 Cleaning and drying. Castings shall be cleaned and dried in accordance with the procedures of MIL-P-116, prior to any preservation.

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## 5.2 Preservation and packaging.

### 5.2.1 Level A.

5.2.1.1 Small castings. Castings weighing less than 150 lbs shall be coated with a P-2 preservative in accordance with MIL-P-116 and individually wrapped in Grade A greaseproof barrier material conforming to MIL-B-121 prior to placing them in containers. Any casting or portion of a casting which may be damaged in shipment shall be properly cushioned with cellulosic material conforming to PPP-C-843.

5.2.1.2 Other castings. Castings weighing over 150 lbs will not require packaging.

### 5.2.2 Level B. Not applicable.

5.2.3 Level C. Castings shall be preserved and packaged in accordance with manufacturer's commercial practice.

## 5.3 Packing.

### 5.3.1 Level A.

5.3.1.1 Small castings. Castings packaged in accordance with 5.2.1.1 shall be packed in cleated plywood or nailed wood boxes conforming to PPP-B-601 (overseas type) or PPP-B-621 (Class 2). Shipping containers shall be lined with a sealed waterproof case liner conforming to Class 2 of MIL-L-10547 and sealed in accordance with the appendix thereto. Gross weight of the shipping container shall not exceed 200 lbs.

5.3.1.2 Other castings. Castings weighing more than 150 lbs and subject to damage in shipment shall be packed individually, or in multiple units with adequate blocking and bracing in cleated-plywood boxes, nailwood boxes, or open wood crates conforming to PPP-B-601 (overseas type), PPP-B-621 (Class 2), or MIL-C-132, as applicable. The casting shall be securely bolted, braced, blocked, or strapped to prevent shifting or damage within the container. The gross weight shall not exceed 500 lbs unless individual castings exceed this weight.

### 5.3.2 Level B.

5.3.2.1 Small castings. Castings weighing less than 150 lbs and packaged in accordance with 5.2.1.1 shall be packed in wirebound wood, cleated-plywood, or nailed wood boxes conforming to PPP-B-585, PPP-B-601 (domestic type), or PPP-B-621 (class 1), respectively. Gross weight of shipping container shall not exceed 200 lbs.

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5.3.2.2 Other castings. Castings weighing more than 150 pounds shall be packed in cleated-plywood boxes, nailed wood boxes, or open wood crates conforming to PPP-B-601 (domestic type), PPP-B-621 (Class 1), or MIL-C-132, respectively. The castings shall be securely bolted, blocked, braced, or strapped to prevent shifting or damage within the container. The gross weight should not exceed 500 lbs unless individual castings exceed this weight.

5.3.3 Industrial. The castings shall be packed in accordance with the requirements of MIL-STD-1188.

5.4 Marking. In addition to any special marking required by the contract or order (see 6.2), shipping containers shall be marked in accordance with MIL-STD-129.

## 6. NOTES

6.1 Intended use. This specification covers a grade of spheroidal graphite iron intended for use where maximum notch toughness is required. It is recommended that the iron covered by this specification be used only where notch toughness is essential.

## 6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, date and number of this specification
- b. Mechanical properties, if different from 3.3
- c. Applicable drawings or dimensions of castings
- d. Size of tension and impact test specimens required (see 4.3.1.4.2)
- e. Place of inspection and test, if different from 4.4.4
- f. Required levels of packaging and packing (see 5.2 and 5.3)
- g. Special marking, if different from 5.4

## 6.3 Materials and manufacturing process.

6.3.1 Materials. Pig iron of the following composition has been used for making nodular graphitic iron castings covered by this specification.

Carbon	- 3.50-4.25 percent
Sulfur	- 0.035 percent maximum
Phosphorus	- 0.035 percent maximum
Silicon	- 1.0 percent approximate
Titanium	- 0.06 percent maximum

6.3.1.1 Subversive elements. The following elements are considered to have a deleterious effect upon nodularization: Antimony, lead, bismuth, titanium, arsenic, copper, chromium, and tin. Every effort should be made to use raw materials free of these elements and also to keep them from contaminating the cast iron melt. Very small percentages of mischmetal additions in the order of one and one-half ounces per ton can overcome the adverse effects of these elements.



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**6.3.2 Manufacture.** Nodular graphite cast iron is ordinarily made by adding either magnesium or cerium to the molten iron. Magnesium is usually added as a master alloy (Ni-Mg or Fe-Si-Mg), while cerium is added as mischmetal. A more recently developed method is the adding of pure magnesium powder to the molten iron in a sealed ladle. Following the addition of the nodulizing agent, the melt is treated with silicon by adding ferro-silicon or calcium silicon alloy. NOTE: The addition of magnesium to molten iron is hazardous and suitable precautions must be observed.

**6.3.3 Castability.** Nodular iron may be used for casting intricate shapes. Its castability is similar to that of some casting brasses and bronzes, slightly less than gray iron and better than steel castings.

**6.4 Heat treatment.** The following heat treatment procedure is given for information purposes only as a guide in producing fully ferritic nodular graphitic iron castings:

Heat casting to 1650°F (889°C), hold at this temperature for a minimum of two hours per inch of cross section; cool in furnace to 1350 - 1275°F (732 - 691°C) and hold this temperature for 15 to 24 hours; cool in furnace to below 700°F (371°C); the castings may then be cooled in air to room temperature.

**6.5 Temper embrittlement in nodular cast irons.** Some irons covered by this specification, heat treated in accordance with 6.4 are embrittled when given further heat treatment such as stress relieving at temperatures within the range 742 - 1112°F (400 - 600°C). Maximum embrittlement is obtained in the temperature range 842 - 932°F (450 - 500°C). This embrittlement may reduce the notch toughness of the iron castings below minimum requirements of this specification. Therefore, for these irons, stress-relief heat treatment should be performed at temperatures not within the embrittlement temperature range and these irons should not be selected for service where these iron castings are heated in use to temperatures within the embrittlement temperatures range.

**6.6 Preparation for delivery criteria.** Criteria for use of the proper level of packaging and packing shall be as follows:

**6.6.1 Level A.** This level shall be used for those items which are to be shipped to indeterminate destinations or stores under indeterminate conditions for redistribution anywhere.

**6.6.2 Level B.** This level shall be used for protection against damage during multiple domestic shipments, handling, and covered storage.

**6.6.3 Level C (industrial).** This level shall be used only when it is definitely known that the packaged item is to be shipped to domestic installations for immediate use at the first receiving activity.

Custodian:  
Army - MR  
Review activity:  
Army - AR, SM

Preparing activity:  
Army - MR  
Project No. MECA-A091

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