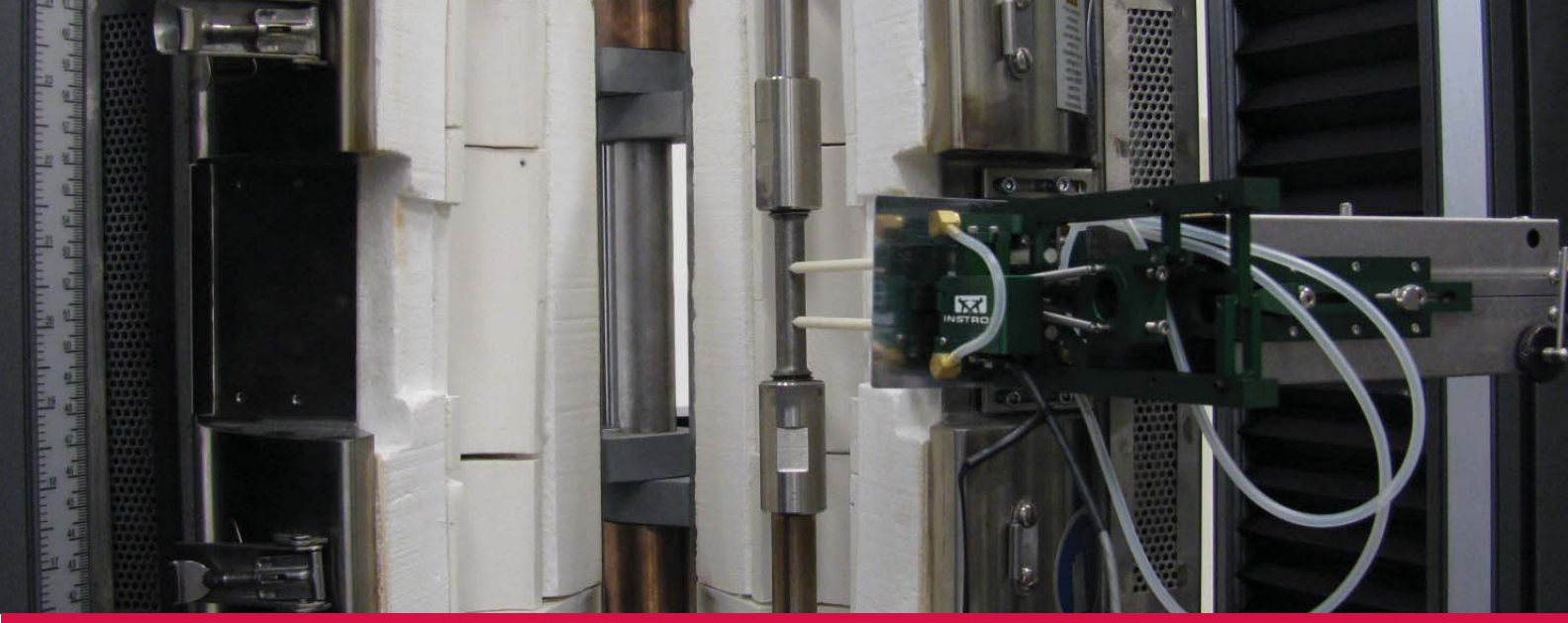


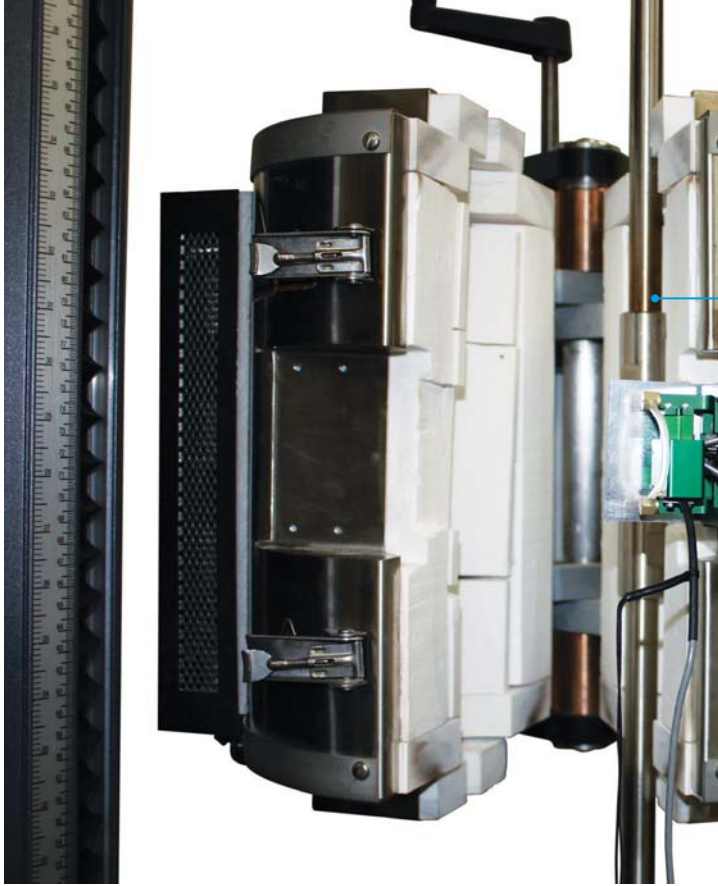
A Guide to High-Temperature Tensile Testing

INSTRON®

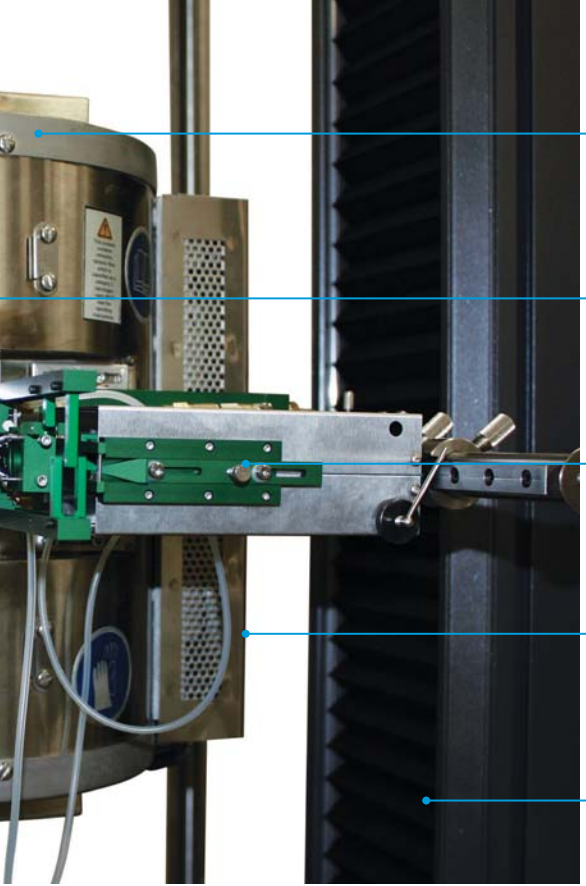
A Guide to High-Temperature Tensile Testing

High-temperature properties of materials are a vital concern in many applications such as power generation, aerospace, and automotive. A full range of furnaces, grips, pull rods, and extensometry is available to provide the complete solution to your high-temperature tensile testing requirements.

This guide explains the various components of a high-temperature tensile testing system along with their capabilities, as well as describes how to perform a test. An important system configuration tool is provided at the end of the guide.



The SF-16 furnace on a 250 kN electromechanical frame with high-temperature E-series Extensometer. Load string consists of quick change adapters, high-temperature pull rods, and threaded specimen end-holders.



Furnaces

The 1200 °C (2200 °F) Model SF-16 three-zone resistance furnaces have a split construction design that facilitates fast and easy loading of a pre-assembled load string. Adjustable stainless steel latches keep the furnace halves locked together during use, but are then easily opened once testing is complete. The furnace case is constructed of stainless steel and aluminum with hardened insulation end plates. To accommodate the use of side-entry, high-temperature extensometers, an optional front cutout (port) is available. The furnace is available for use on any Instron® Electromechanical floor model tensile system with mounting that includes swing-away capability, vertical adjustment, and mechanical alignment features. The SF-16 is suitable for testing flat, threaded or buttonhead specimens at temperatures up to 1050 °C (at the specimen) for short durations.

An important component of the furnace is a thermocouple that works on the principle of the thermoelectric effect; a voltage is created when a metal is heated. When two dissimilar metals are joined, there will be a difference in voltage at the juncture, which can be used to determine the temperature at the juncture. With three type K (made from Chromel-Alumel) thermocouples in the wall of the SF-16 furnace, three temperature zones are available and can be controlled independently with the W-C015-BK controller. Additional thermocouples are available that can be attached directly to the specimen, by means of ceramic fiber cord or thermocouple wire. This allows the temperature to not only be measured but also controlled, directly at the specimen surface.

SF-16 Furnace Control

Catalog Number	Description
W-C015-BK	Control System for Type K thermocouples
W-7743	Type K thermocouples
W-C015-BR	Control System for Type R thermocouples
W-7744	Type R thermocouples

SF-16 Furnaces

Catalog Number	Description	Temperature Rating		Internal Dimensions		External Dimensions	
		°C	°F	mm	in	mm	in
W-8711-B	Furnace with Type K thermocouples	+1200	+2200	76 × 280	3 × 11	254 × 330	10 × 13
W-8711-F	Furnace with Type K thermocouples and extensometer port	+1200	+2200	76 × 280	3 × 11	254 × 330	10 × 13
S4-6292	Furnace with Type R thermocouples and extensometer port	+1200	+2200	76 × 280	3 × 11	254 × 330	10 × 13

Designed to work with the SF-16 furnace's three heat zones, these temperature control systems (W-C015 -BK shown above) consist of three model 2416 Eurotherm® controllers for independent control of each zone. Zero-cross SCRs are used for stable high-current control of power going to the furnace/chamber heating elements. The electrical isolation and heat sink cooling design offers long life and stability, which is very important for testing applications of lengthy duration.

Quick Tip -

Additional thermocouples are required to control the temperature at the specimen surface.

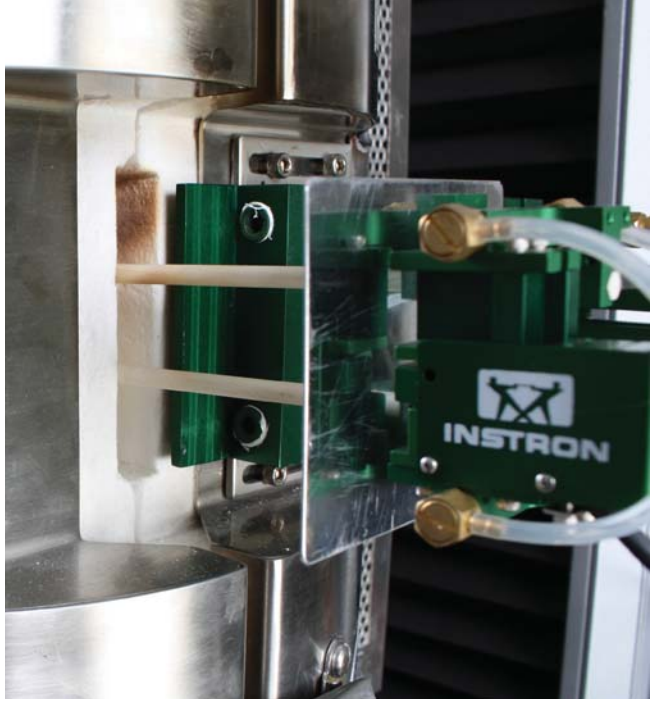
SF-16 Three-zone furnace can reach temperatures up to 1200°C (2200 °F)

Extensometry

There are several choices for extensometry, depending on your needs. The E-Series extensometers must be used with the SF-16 furnace with the extensometer port (W-8711-F or S4-6292). The W-6183 or W-C016-F vertical extensometers are used with furnaces without the port (W-8711-B).

The W-418 (3448) is self supporting and uses flexible ceramic fiber cords to hold the ceramic arms in contact with the specimen. The E-series 3548HI mounts to the furnace or T-slot mounting arm (CP109041) and uses spring force to maintain contact with the specimen. The gauge length can be set prior to mounting, so it can be mounted on specimens after they are heated, mitigating thermal expansion issues, and can be easily removed before fracture to prevent damage to the arms. Water cooling helps to improve measurement accuracy at extremely high temperatures, but is generally not necessary.

The W-6183 and W-C016-F extensometers attach to the specimen prior to heating and have arms that hang out the bottom of the furnace. A measuring unit (typically a standard clip-on or LVDT) is then attached to these arms outside the heated zone. This allows for the use of standard extensometry and is more economical when using multi-furnace systems since only one measuring device is needed and it can be moved to the subsequent specimen.



The E-Series 3548HI extensometer uses strain-gage technology and can be hot-loaded after letting the specimen heat-soak. Correspondingly, it can easily be removed from the specimen before fracture, greatly improving the life of the ceramic knife edges which contact the specimen.

Extensometers

Catalog Number	Description	Gauge Length	Measuring Range
		in or mm	%
W-E418-1	E-Series 3448 High-Temperature 1200 °C (2200 °F) Maximum Temperature Self-Supporting with Ceramic Cord	1.0 in	±20
W-E418-2		2.0 in	±20
W-E418-25		25 mm	±20
W-E418-50		50 mm	±20
CP10911	E-Series 3548HI High-Temperature Water Cooled 1200 °C (2200 °F) Maximum Temperature Counter-balanced Hot Loadable	1.0 in	±20
CP109912		2.0 in	±20
CP108643		25 mm	±20
CP107717		50 mm	±20
W-6183	Model PSH-8MS Separable, Non-Averaging LVDT Measuring Unit (Requires W-6185 or W-6189 suspension arms for specific specimen dimensions.)	1.0 or 2.0 in	0.04 in
W-C016-F	RT-214 High-Temperature Rod and Tube-Style Extensometer (Requires knife edge inserts for specific specimen dimensions. See W-C016-C/-J1/-J2/-J3.)	10 to 152 mm	Requires Clip-on Extensometer

Quick Tip -
Water cooling helps to improve strain measurement accuracy at extremely high temperatures, but is generally not necessary.

RT-214 High-Temperature Rod and Tube-Style Extensometer clamps to the specimen and extends through the bottom of the furnace where the strain sensing element (extensometer or LVDT) is attached.

Specimen Holders

Threaded-end specimen holders allow for simple mounting of round specimens and are available in metric and US customary thread sizes.

Pin-and-clevis specimen holders are available in a range of sizes for flat, dumbbell specimens.

Pin-and-clevis specimen holders

Threaded-end specimen holders

Specimen Holders

Catalog Number	Description	Range of Dimensions
W-7551-C	Threaded-end	Metric: M6 to M19 US Customary: #10 to 0.750 in (see list at end)
W-7553-C	Pin and clevis	Thickness: 3 - 10 mm (0.125 - 0.375 in) Pin Diameter: 3 - 10 mm (0.125 - 0.375 in)
W-7553-CT	Pin and clevis (for thin specimens)	Thickness: 0.8 - 3 mm (0.031 - 0.120 in) Pin Diameter: 3 - 10 mm (0.125 - 0.375 in)

Quick-Change Adapters

Catalog Number	Load Cell and Base Fitting
W-7556M2	6 mm clevis pin (Type 0m)
W-7556M4	12.5 mm clevis pin (Type Dm)
W-7556M6	16 mm clevis pin (Type 1m)
W-7556M8	M48 LH (Type IIm)

Quick Tip -

Testing throughput can be dramatically improved when multiple load strings are prepared, eliminating the downtime associated with the cooling of specimen holders and pull rods after test (additional holders, pull rods and washers are required).

Pull Rods

A variety of pull rods and specimen adapters are available to accommodate various specimen geometries. They are made of special high-temperature materials for durability and ease of use. Specimen Holders are easily removed from the pull rods to allow rapid interchange of flat, threaded, or buttonhead specimen shapes.

Quick-Change Adapters

Spherically-seated, quick-change adapters allow for the entire specimen pull rod assembly to be removed after testing and for immediately installing the next assembly - quickly and easily. This minimizes the time required for the furnace to return to temperature, decreasing the time between tests, while greatly improving throughput and efficiency.

Inconel pull rods can withstand 9070 kgs (20,000 lbs) load up to 760°C (1400°F) and 1360 kgs (3000 lbs) load up to 1100°C (2000°F).

The Spherically Seated Quick Change Adapters will self-align load strings that are misaligned up to 4 degrees.

Pull Rods

Catalog Number	Length	
	mm	in
W-7546-C	273	10.75

Mountings

Mounting the SF-16 furnace to the test frame is an important consideration; and there are two options to choose from. The standard mounting allows the operator to set the vertical position of the furnace, while the advanced mounting contains additional features for more precise positioning. Both options offer a swing-away capability to easily remove the furnace from the testing space.

The major feature of the advanced mounting option is the vertical adjustment hand-crank that allows for quick and easy positioning of the furnace height. The hand-crank provides convenient, fine adjustment of the furnace height with minimal effort. This ensures that each specimen is centered in the heating zone, providing an even and consistent heating of the entire specimen.

Another advantage of the advanced option is a lower mounting collar to set the alignment of the vertical mounting bar for simple and precise positioning of the furnace to ensure parallelism with the load-string and specimen.


Hand-crank for fine vertical positioning


Adjustable lower mounting collar ensures parallelism with load string

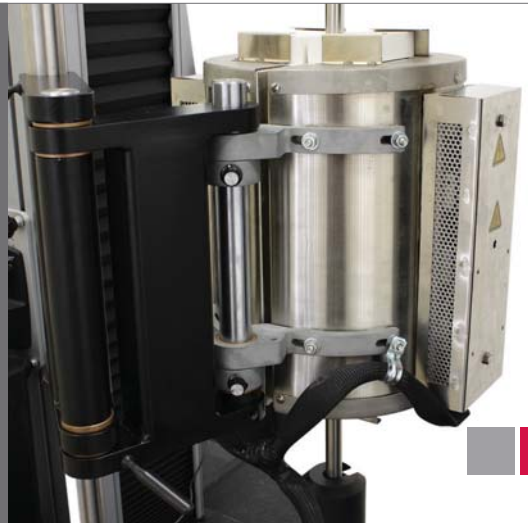
Quick Tip -
When testing specimens of varying sizes, the vertical adjustment hand-crank found on the advanced mounting is invaluable.

Advanced Mounting

Mountings

Catalog Number		Frame Models
Advanced	Standard	
CP103350	CP104512	5581/82/84/85H E1 & E2 Not for 5587/89 or 5900
CP107737	CP106773	5982/84/85 E1 Not for 5988/89
CP106870	CP107027	5982/84/85 E2 Not for 5988/89
NA	CP107143	5967 E2 F2
CP103122	NA	xx87/88/89 E1 & E2

Standard Mounting



Configuration of Your System

Configuring a high-temperature testing system can easily be accomplished using the information below as a guide. Base your selection on the materials and standards you are testing to. Still have questions or don't see what you are looking for? Call us for assistance - 1.800.564.8378

Furnace

Select 1

- [ ] W-8711-B, SF-16 furnace with type K thermocouples
- [ ] W-8711-F, SF-16 furnace with Type K thermocouples and extensometer port
- [ ] S4-6292 SF-16 furnace with Type R thermocouples and extensometer port

Furnace Control

- [ ] W-C015-BK, Control System for Type K thermocouples
- [ ] W-7743, Type K thermocouples (optional)
- [ ] W-C015-BR, Control System for Type R thermocouples
- [ ] W-7744, Type R thermocouples (optional)
- [x] IP-2005 labels, markings, manuals*

*required

Extensometry

Unlimited Selection

- [ ] W-E418-1, E-Series 3448 Self-Supporting Ceramic Cord
- [ ] W-E418-2, E-Series 3448 Self-Supporting Ceramic Cord
- [ ] W-E418-25, E-Series 3448 Self-Supporting Ceramic Cord
- [ ] W-E418-50, E-Series 3448 Self-Supporting Ceramic Cord
- [ ] CP109911, E-Series 3548 HI Hot loadable. Can be water cooled.
- [ ] CP109912, E-Series 3548HI Hot loadable. Can be water cooled.
- [ ] CP108643, E-Series 3548HI Hot loadable. Can be water cooled.
- [ ] CP107717, E-Series 3548HI Hot loadable. Can be water cooled.
- [ ] W-6183, Model PSH-8MS Separable, Non-Averaging LVDT Measuring Unit
- [ ] W-C016-F, Model RT-214 High-Temperature Rod and Tube Mechanical Averaging Extensometer

Quick-Change Adapters

Enter quantities -
Minimum 2 required (1 upper & 1 lower)

- ☐ W-7556M2, 6 mm clevis pin (Type 0m)
- ☐ W-7556M4, 12.5 mm clevis pin (Type Dm)
- ☐ W-7556M6, 16 mm clevis pin (Type 1m)
- ☐ W-7556M8, M48 LH (Type IIm)

Pull Rods

Enter quantities -
Minimum 2 required (1 upper & 1 lower)

- ☐ W-7546-C, 273 mm (10.75 in)

Mounting

Select 1

- ☐ CP104512, Standard, 5581/82/84/85H E1 & E2. Not for 5587/89 or 5900
- ☐ CP106773, Standard, 5982/84/85 E1. Not for 5988/89
- ☐ CP107027, Standard, 5982/54/85 E2. Not for 5988/89
- ☐ CP107143, Standard, 5967 E2 F2
- ☐ CP103350, Advanced, 5581/82/84/85H E1 & E2. Not for 5587/89 or 5900
- ☐ CP107737, Advanced, 5982/54/85 E1. Not for 5988/89
- ☐ CP106870, Advanced, 5982/84/85 E2. Not for 5988/89
- ☐ CP103122, Advanced, xx87/88/89 E1 & E2

Specimen Holders

Enter quantities - Minimum 2 required (match to specimen)

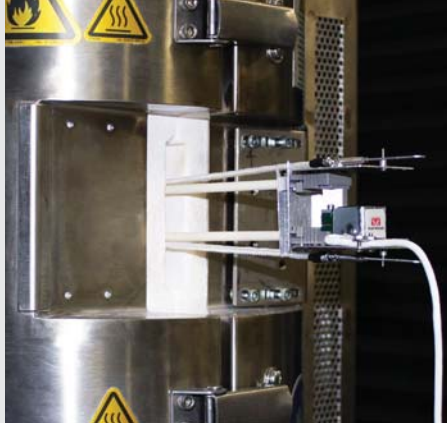
- ☐ W-7553-C, Pin and clevis*
- ☐ W-7553-CT, Pin and clevis for thin specimens*
- ☐ W-7551-CM1, M6 × 1.0
- ☐ W-7551-CM2, M8 × 1.0
- ☐ W-7551-CM3, M8 × 1.25
- ☐ W-7551-CM4, M10 × 1.5
- ☐ W-7551-CM5, M12 × 1.5
- ☐ W-7551-CM6, M12 × 1.75
- ☐ W-7551-CM7, M14 × 2.0
- ☐ W-7551-CM8, M16 × 1.5
- ☐ W-7551-CM9, M16 × 2.0
- ☐ W-7551-CM10, M18 × 2.5
- ☐ W-7551-CM11, M19 × 1.5
- ☐ W-7551-CU1, 10 - 24
- ☐ W-7551-CU2, 10 - 32
- ☐ W-7551-CU3, 1/4 - 20
- ☐ W-7551-CU4, 1/4 - 28
- ☐ W-7551-CU5, 5/16 - 24
- ☐ W-7551-CU6, 5/16 - 18
- ☐ W-7551-CU7, 3/8 - 16
- ☐ W-7551-CU8, 3/8 - 24
- ☐ W-7551-CU9, 7/16 - 14
- ☐ W-7551-CU10, 1/2 - 13
- ☐ W-7551-CU11, 5/8 - 11
- ☐ W-7551-CU12, 3/4 - 10

* Supplied as a set of (2)

Furnace

Furnace Control System

Extensometry



Keep track of your configuration

Quick-Change Adapters

Pullrods

Mounting

Specimen Holders

Configuration Worksheet

Write down the catalog number of each item to easily identify the product to your Instron® representative...

Model Frame _____

Furnace _____

Furnace Control System _____

Extensometry _____

_____

Quick-Change Adapters _____

_____

Pullrods _____

Mounting _____

Specimen Holders _____

_____

www.instron.com

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Worldwide Headquarters
825 University Avenue
Norwood, MA 02062-2643 USA
+1 800 564 8378 • +1 781 575 5000

European Headquarters
Coronation Road, High Wycombe
Bucks, HP12 3SY UK
+44 1494 464646

Industrial Products Group
900 Liberty Street
Grove City, PA 16127 USA
+1 800 726 8378 • +1 724 458 9610

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