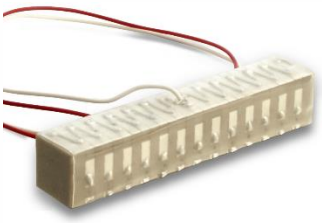
# Linear Actuators

## Damage Tolerant Stacks

### Features

- Fuse technology ensuring high reliability
- Displacement up to 128.7 µm
- Very high force in the kN range
- High stiffness for short response times (<1ms)
- Height up to 80 mm



### Applications

- Micro- and nanopositioning
- Industrial equipment
- Active vibration control
- Valves
- Laser tuning
- Shaker

### Description

CTS tape cast multilayer piezoelectric linear actuators are ideal for a wide range of electronic designs requiring precise and fast movement. The fuse technology is an effective way to ensure high reliability for critical applications. Thanks to the technology of damage tolerant piezo actuator stacks, the application keeps working even if a section of the actuator is damaged. The fuse technology fuses out any damaged ceramic element and the remaining ceramic elements of the stack continue to operate.

### Standard Product, add-ons or Custom Solution

This document contains information about the CTS standard multilayer damage tolerant stacks and available add-ons. All the CTS multilayer products can be custom designed to match specific requirements – find more information on www.ctscorp.com or contact your local sales representative.

## Product Designation

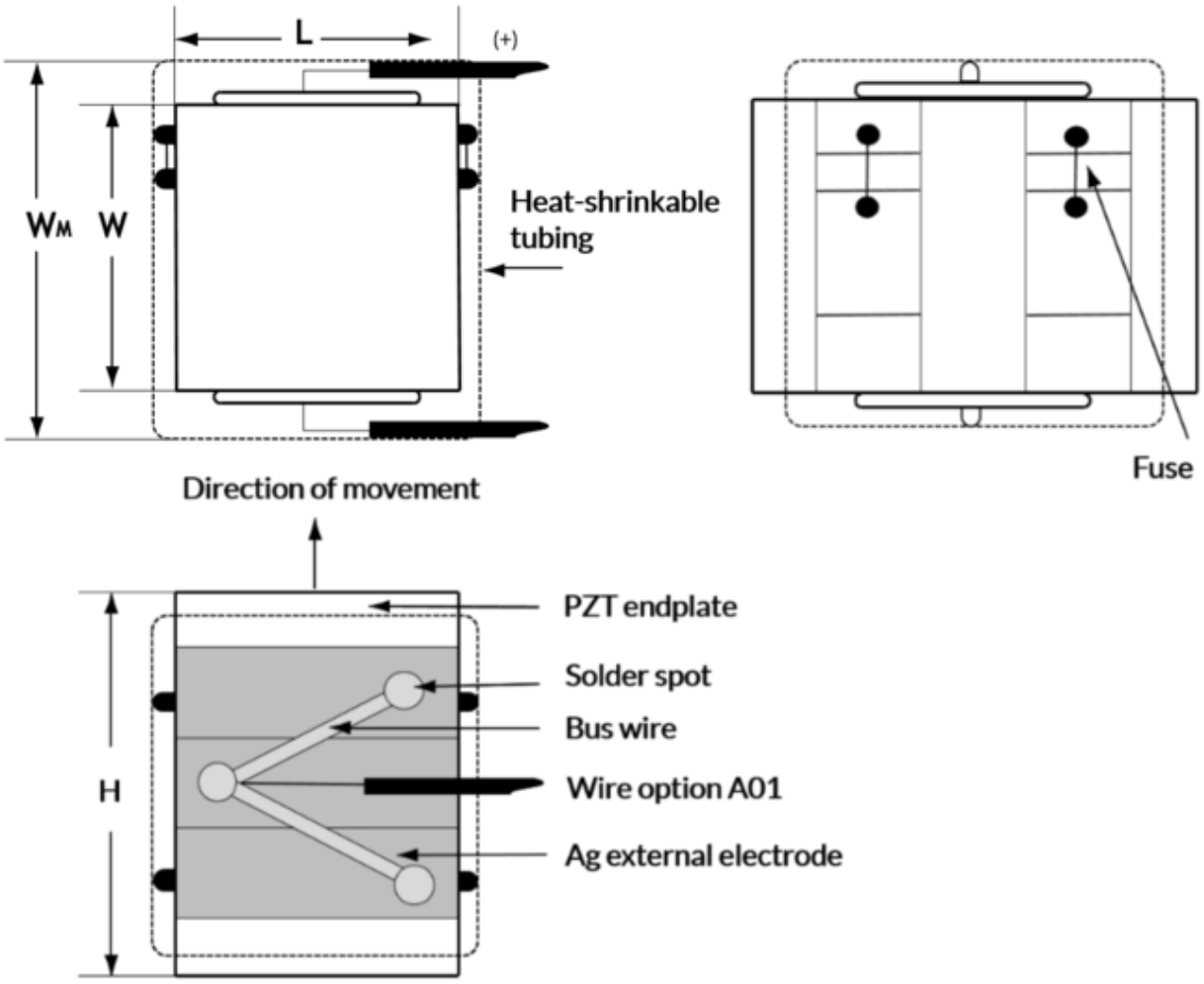
NAC5021-H20-A01


## Specifications

| Product series | NAC5021-HXX | NAC5022-HXX | NAC5023-HXX | Unit |
|---|---|---|---|---|
| Length (L) | 7 +0.35/-0.15 | 10 +0.40/-0.20 | 15 +0.50/-0.30 | mm |
| Width (W) | 7 +0.35/-0.15 | 10 +0.40/-0.20 | 15 +0.50/-0.30 | mm |
| Max width/length ($W_M$) | 9.56 Max | 12.8 Max | 17.9 Max | mm |
| Height (H) | 6 to 70*<br>+/-0.2 or 1% (whichever is largest) | 6 to 80*<br>+/-0.2 or 1% (whichever is largest) | 6 to 80*<br>+/-0.2 or 1% (whichever is largest) | mm |
| Operating voltage, $V_{max}$ | 200 | | | V |
| Blocking force, 0 to $V_{max}$ | 2060 +/-20% | 4200 +/-20% | 9450 +/-20% | N |
| Max. operating temp. | 150 | | | °C |
| PZT material | NCE51F | | | - |
| External electrodes | Screen-printed silver, tinned copper bus-wire | | | - |

* See the different height options and corresponding free displacement and capacitance data in the tables below.

## Drawing




Note: product represented with wires in A01 configuration.

## Stacking Options

| NAC5021-Hxx | | |
|---|---|---|
| Height | Free Stroke | Capacitance |
| +/-0,2 mm or 1%* | +/-15% | +/-15% |
| mm | µm | nF |
| 6 | 6.6 | 400 |
| 8 | 9.9 | 590 |
| 10 | 13.2 | 790 |
| 12 | 16.5 | 990 |
| 14 | 19.8 | 1190 |
| 16 | 23.1 | 1390 |
| 18 | 26.4 | 1580 |
| 20 | 29.7 | 1780 |
| 22 | 33.0 | 1980 |
| 24 | 36.3 | 2180 |
| 26 | 39.6 | 2380 |
| 28 | 42.9 | 2570 |
| 30 | 46.2 | 2770 |
| 32 | 49.5 | 2970 |
| 34 | 52.8 | 3170 |
| 36 | 56.1 | 3370 |
| 38 | 59.4 | 3560 |
| 40 | 62.7 | 3760 |
| 42 | 66.0 | 3960 |
| 44 | 69.3 | 4160 |
| 46 | 72.6 | 4360 |
| 48 | 75.9 | 4550 |
| 50 | 79.2 | 4750 |
| 52 | 82.5 | 4950 |
| 54 | 85.8 | 5150 |
| 56 | 89.1 | 5350 |
| 58 | 92.4 | 5540 |
| 60 | 95.7 | 5740 |
| 62 | 99.0 | 5940 |
| 64 | 102.3 | 6140 |
| 66 | 105.6 | 6340 |
| 68 | 108.9 | 6530 |
| 70 | 112.2 | 6730 |

| | NAC5022-Hxx | | NAC5023-Hxx | |
|---|---|---|---|---|
| Height | Free Stroke | Capacitance | Free Stroke | Capacitance |
| +/-0,2 mm or 1%* | +/-15% | +/-15% | +/-15% | +/-15% |
| mm | µm | nF | µm | nF |
| 6 | 6.6 | 790 | 6.6 | 1750 |
| 8 | 9.9 | 1190 | 9.9 | 2620 |
| 10 | 13.2 | 1580 | 13.2 | 3490 |
| 12 | 16.5 | 1980 | 16.5 | 4370 |
| 14 | 19.8 | 2380 | 19.8 | 5240 |
| 16 | 23.1 | 2770 | 23.1 | 6110 |
| 18 | 26.4 | 3170 | 26.4 | 6980 |
| 20 | 29.7 | 3560 | 29.7 | 7860 |
| 22 | 33.0 | 3960 | 33.0 | 8730 |
| 24 | 36.3 | 4360 | 36.3 | 9600 |
| 26 | 39.6 | 4750 | 39.6 | 10480 |
| 28 | 42.9 | 5150 | 42.9 | 11350 |
| 30 | 46.2 | 5540 | 46.2 | 12220 |
| 32 | 49.5 | 5940 | 49.5 | 13100 |
| 34 | 52.8 | 6340 | 52.8 | 13970 |
| 36 | 56.1 | 6730 | 56.1 | 14840 |
| 38 | 59.4 | 7130 | 59.4 | 15710 |
| 40 | 62.7 | 7520 | 62.7 | 16590 |
| 42 | 66.0 | 7920 | 66.0 | 17460 |
| 44 | 69.3 | 8320 | 69.3 | 18330 |
| 46 | 72.6 | 8710 | 72.6 | 19210 |
| 48 | 75.9 | 9110 | 75.9 | 20080 |
| 50 | 79.2 | 9500 | 79.2 | 20950 |
| 52 | 82.5 | 9900 | 82.5 | 21830 |
| 54 | 85.8 | 10300 | 85.8 | 22700 |
| 56 | 89.1 | 10690 | 89.1 | 23570 |
| 58 | 92.4 | 11090 | 92.4 | 24440 |
| 60 | 95.7 | 11480 | 95.7 | 25320 |
| 62 | 99.0 | 11880 | 99.0 | 26190 |
| 64 | 102.3 | 12280 | 102.3 | 27060 |
| 66 | 105.6 | 12670 | 105.6 | 27940 |
| 68 | 108.9 | 13070 | 108.9 | 28810 |
| 70 | 112.2 | 13460 | 112.2 | 29680 |
| 72 | 115.5 | 13860 | 115.5 | 30560 |
| 74 | 118.8 | 14260 | 118.8 | 31430 |

| | | | | |
|---|---|---|---|---|
| 76 | 122.1 | 14650 | 122.1 | 32300 |
| 78 | 125.4 | 15050 | 125.4 | 33170 |
| 80 | 128.7 | 15440 | 128.7 | 34050 |

* whichever is largest

Stack heights exceeding listed values on request.

# Add-ons

## Wire Options

When you order damage tolerant actuator stacks from CTS, they are delivered with wires. Therefore, when you order, you have to select one of our wire options. However, you should consider these parameters, when you select a wire for connection:

- Operation voltage
- Intensity of current
- Operating temperature
- Environment for example vacuum

### We recommend wires with PTFE insulation

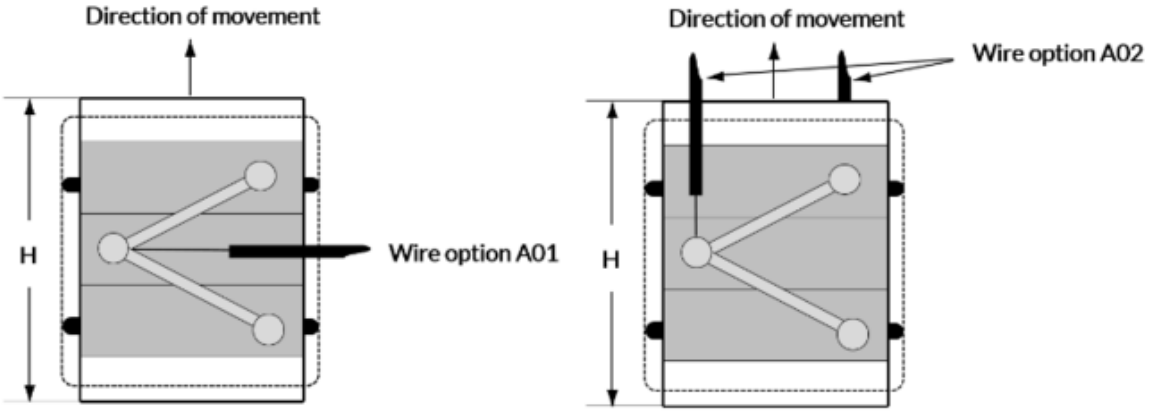
PTFE wires can stand temperatures above 200 °C, whereas PVC wires only resist temperatures up to 80 °C. We recommend PTFE for the thermal and chemical resistance of the insulation.

For vacuum and cryogenic applications, we recommend Kapton wires, which offer superior outgassing and flexibility.

### Standard wire options for Damage Tolerant Stacks

Two standard wire options are available:

| | Option A01 | Option A02 |
|---|---|---|
| Wire type | MIL-W-16878/4, 28 AWG, 7 strands | |
| Length | 200mm +/-10mm | |
| Position | Middle of the actuator | |
| Direction | Perpendicular to the height | Toward the top |



## Wire gauge (AWG)

The wire gauge (AWG) and insulation type should be determined according to the voltage, current and operating environment. Should the standard –A01 or –A02 configuration not suit your application, we offer several alternative wire types:

| Wire type | Voltage rating [V] | Approx. outer diameter [mm] | Rec. max. current [A] | Min. operating temperature [°C] |
|---|---|---|---|---|
| 32AWG, MIL-W-16878/6, 7 strands | 250 | 0.6 | 0.53 | -60 |
| 30AWG, MIL-W-16878/4, 7 strands | 600 | 0.8 | 0.86 | -60 |
| 28AWG, MIL-W-16878/4, 7 strands | 600 | 0.9 | 1.4 | -60 |
| 28AWG, Allectra 311-KAPM-035 (Kapton insulation, UHV) | 1000* | 0.5 | 1.0 | -269 |
| 22AWG, BS3G210 Type A, 19 strands | 300 | 1.1 | 8 | -75 |

* In vacuum conditions

As part of our custom program, we can also stock specific wire.

## Reduced tolerances

For demanding applications, piezoelectric actuators can be re-worked after stacking in order to achieve better geometrical and dimensional properties. CTS offer this customization possibility for damage tolerant stacks with cross sections of 7x7 mm and 10x10 mm.

| Product series | Standard height tolerance | Reduced height tolerance |
|---|---|---|
| NAC5021 | +/-0.2mm or +/-1%* | +/-0.040mm |
| NAC5022 | +/-0.2mm or +/-1%* | +/-0.050mm |

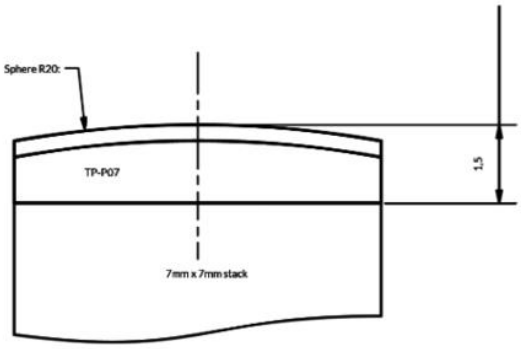
* whichever is largest

## End-pieces

Metallic end-pieces can be useful in terms of:

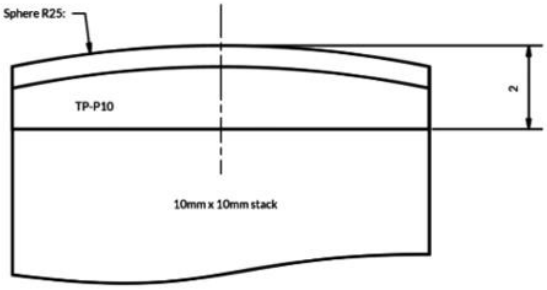
- Spreading a high mechanical load on the whole surface of an actuator
- Providing some de-coupling, i.e. allowing a stack to tilt
- Centering an actuator in an assembly

CTS stock end-pieces for our most popular cross-sections (5x5, 7x7 and 10x10 mm). The material is stainless steel (AISI 316). These products are compatible with:




End-piece TP-P07: 7x7 mm

NAC5021-Hxx




End-piece TP-P10: 10x10 mm

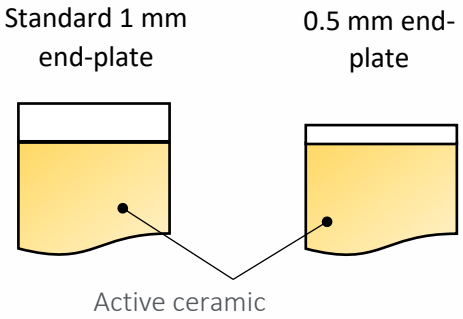
NAC5022-Hxx

The design is compact, with spherical caps providing some de-coupling, thereby releasing the requirements on alignment. The parts are low-magnetic and compatible with our other add-ons. End-pieces can be attached at one or both ends of a stack. They can be supplied with a short lead-time and are more cost-effective for small series.

## End-plates

As a standard, damage tolerant stacks are supplied with 1mm thick ceramic end-plates. All our standard end-plates and end rings are produced with our piezoceramic material NCE51. Ceramic provides ideal electrical insulation properties, low thermal expansion mismatch as well as good mechanical properties to spread the load over the surface of the active piezoceramic. We recommend a thickness of 1 mm for a good spread of the load.

It is nevertheless possible to use different configurations as illustrated below:



## Storage

We recommend storing piezoelectric ceramic components in a cool and dry environment to avoid tarnishing of the silver electrodes. The ceramic material itself is not affected by humidity, as long as no voltage is applied. If components have been stored in uncontrolled environment, we recommend drying them thoroughly before use. Heat drying is well adapted, for example 24h at 110°C, if possible in low-pressure environment.

Piezoelectric components can be stored for many years without problem. Piezoelectric ceramic is subject to aging from the date of poling, meaning that performance (capacitance, stroke) will decrease according to a logarithmic trend, typically 2-5% per decade (after 1 day, 10 days, 100 days…).

## Handling

Although damage tolerant stacks are protected by a sleeve, piezoelectric ceramic components are fragile and must be handled with care. We recommend to:

- Prevent the components from hitting each other or hard surfaces, keep components separate
- Particularly for tall, narrow stacks, make sure that no bending is induced
- Use plastic tweezers and tools rather than metallic ones
- Use gloves to avoid contamination
- Do not apply excessive force on the pre-attached wires

When submitted to a force or to temperature changes, be aware that piezoelectric components will generate charge (i.e. voltage when in open circuit), so they must be properly discharged before use. Always discharge through a resistor rather than shorting the wires, as it would create high dynamic forces that can damage the component. It is recommended to keep larger components short-circuited during shipment and storage to avoid charge build-up.

## Cleaning

Damage tolerant stacks are fitted with a protective sleeve and should not require cleaning. For the cleaning of the ceramic end-plates, we recommend isopropyl-alcohol (propanol) or ethanol. Be aware of solvent running under the protective sleeve. The components have to be thoroughly dried before use.

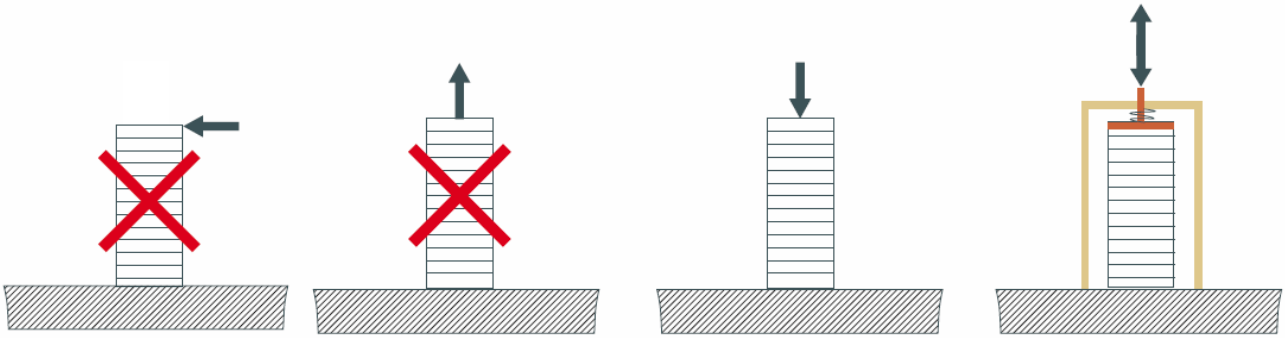
## Mounting

Damage tolerant stacks offer flat and parallel surfaces for mounting. The actuators may be mounted either by mechanical clamping or using adhesive.

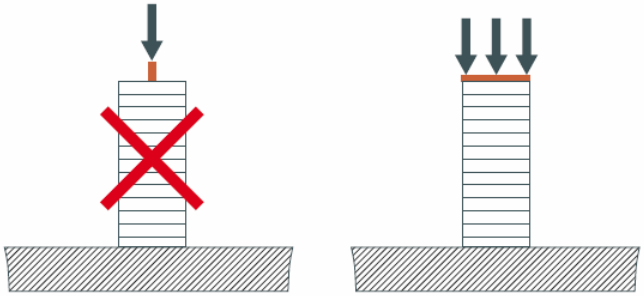
### General recommendations

Piezoelectric ceramics can tolerate high compressive stress, but only limited tensile stress. CTS actuators can be safely operated without preload in quasi-static conditions, however preload is required to achieve the specified stiffness and dynamic performance. We recommend at least 5 MPa preload for quasi-static applications, 10 MPa for dynamic applications and up to 40 MPa in specific high loading conditions.

We recommend to avoid tensile stress, which could result from direct pulling, inertial forces or bending forces. If pull or bending forces cannot be avoided, the actuator must be properly pre-stressed to ensure tensile stress is eliminated. Refer to our online tutorial for additional information on the estimation of stack loads.

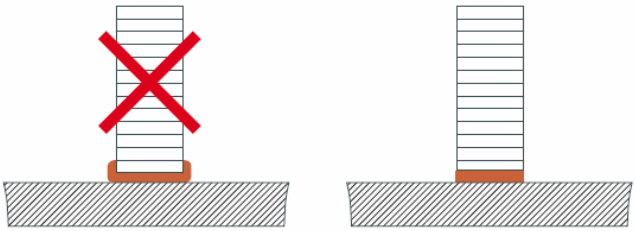


The mechanical load must be applied on the full surface of the actuator in order to avoid stress concentrations.



### Mounting using adhesive

Epoxy adhesives are well suited for mounting piezoceramics. For linear actuators, we recommend using a semi-soft (Shore D hardness 50-70), non-conductive, unfilled epoxy. When bonding, it is important to ensure a very thin glue line between the actuator and the substrate. It is recommended to apply a pressure, e.g. 2-5 MPa, during the curing process. To avoid significant loss of performance, the mounting should avoid adhesive on the sides of the actuator.



## Connecting and Driving

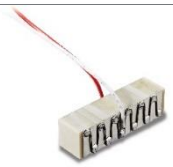
Damage tolerant stacks are easily connected using the attached wires. Ensure that the stacks are properly discharged and that there is no voltage on the output when connecting to a driver. Voltage differences will generate current peaks that can damage the actuator or the driver.

The current capability of the driver must be adapted to the driving signal. Due to the capacitive nature of the piezoelectric actuator, fast motion will often require very high currents. Please refer to our online tutorial for guidance about current calculation.

We recommend to add a resistance in series with the actuator to form a RC circuit to limit the peak current, bandwidth and eventual noise that may be generated by the driver.

## Linear Actuators Product Families


Plate and Ring Actuators




Stacked Actuators:

- Plate Stacks
- Plate stacks, compact
- Ring Stacks
- High Temperature Stacks
- Damage Tolerant Stacks

Preloaded Actuators

Learn more about the different linear actuators product families on www.ctscorp.com.