CathCAD® Hypotube

Superelastic Nitinol Verification Test Report

Revision 00 | 2026.11.17 | Test case RT100914-001 | Job c1116f085f929396

Purpose. Record the CathCAD® Hypotube Superelastic Nitinol–Austenite verification run, compare its outputs with pre-run expectations and analytical checks, and assess whether the selected test case is suitable for verifying material-dependent model behavior.

1. Test Case and Rationale

The selected case uses a small-diameter interrupted helical hypotube with defined geometry and material properties. It exercises four distinct response checks: linear stiffness and crush scaling, the Nitinol recoverable-strain criterion for permanent-set radius, the reported Brazier/kink limit, and geometric kerf-closure kinematics.

Input	Nitinol verification case
Product / model	CathCAD® Hypotube — Interrupted Helical Hypotube V1.9.2
Material card	Superelastic Nitinol – Austenite
Outside diameter Do	2.000 mm
Wall thickness t	0.100 mm
Inside diameter Di	1.800 mm
Helical pitch P	1.000 mm/turn
Kerf k	0.030 mm
Cut angular span	80°
Cuts per turn	3.5
Section length L	4.000 mm (4 turns)
Elastic modulus E	55,000 MPa
Poisson ratio ν	0.33
Yield / plateau stress	475 MPa
Recoverable strain criterion	6.0% (updated setting)
Solver record	RT100914-001; Job c1116f085f929396

Why the case is useful: the same nominal cross-section and interrupted helical pattern can be compared with a 304 stainless steel reference, while the selected Nitinol card invokes the recoverable-strain treatment. Each reported output can also be checked against a separate relationship: modulus scaling, shear-modulus scaling, ring-crush scaling, EA/L, strain-to-radius scaling, or slot-closure geometry. This makes the case effective for checking that CathCAD® Hypotube responds consistently to the selected material card and geometry.

2. Expected and Actual Results

Output	Pre-run expectation	Actual result	Comparison
Flexural rigidity EI	~6,550 N·mm²	6,725.7 N·mm²	+2.7% vs. estimate; 304 reference 23,004 N·mm²
Longitudinal rigidity EA	~15,200 N	15,537.7 N	+2.2% vs. estimate; 304 reference 53,390 N
Torsional rigidity GJ	~8,300 N·mm²	8,407.9 N·mm²	+1.3% vs. estimate; 304 reference 30,050 N·mm²
Axial spring rate EA/L	~3,800 N/mm	3,884.4 N/mm	EA/L = 15,537.7 / 4.000 = 3,884.4 N/mm
Permanent-set bend radius	11.8–12.5 mm	12.121 mm	Within expected range; about 3.0% above 11.77 mm strain-scaling estimate
Failure / kink bend radius	16.5–32.3 mm	32.271 mm	At upper end of expected range; reported as Brazier/kerf-closure governed
Crush resistance at 5%	~2.55 N/mm	2.574 N/mm	About +0.9% vs. pre-run estimate
Governing mode	Kink / closure	Kerf-Closure Before Kink	Closure radius 32.333 mm vs. kink radius 32.271 mm

3. Independent Engineering Checks

3.1 Linear stiffness and crush scaling

The 304 stainless steel reference uses E = 193,000 MPa and ν = 0.29. The Nitinol case uses E = 55,000 MPa and ν = 0.33. The elastic-modulus ratio is 55,000 / 193,000 = 0.2850. The shear-modulus ratio calculated from G = E/[2(1+ν)] is approximately 0.2764. The plane-strain ring-crush ratio calculated from E/(1−ν²) is approximately 0.2930.

Metric	Observed ratio	Reference ratio	Difference from reference
EI: 6,725.7 / 23,004	0.2924	0.2850	+2.6%
EA: 15,537.7 / 53,390	0.2910	0.2850	+2.1%
GJ: 8,407.9 / 30,050	0.2798	0.2764	+1.2%
Crush: 2.574 / 8.65	0.2976	0.2930	+1.6%

These are close to the material-property scaling estimates. The crush result is close but is not an exact match to the stated closed-form ratio. The EI, EA, GJ, and crush comparison uses the provided 304 stainless steel Case 3 values; see the comparison limitation in Section 5.

3.2 Permanent-set bend radius

For 304 stainless steel, the stated permanent-set strain estimate is σy/E + 0.002 = 230/193,000 + 0.002 = 0.003192, corresponding to the provided 221.2 mm reference radius. Scaling inversely with the 6.0% Nitinol recoverable-strain criterion gives 221.2 × (0.003192/0.060) = 11.77 mm. The reported 12.121 mm is about 3.0% above this estimate and falls within the stated pre-run range of 11.8–12.5 mm.

This check verifies consistency with the configured 6.0% criterion. It does not independently establish a universal recoverable-strain limit for all Nitinol materials or product conditions.

3.3 Kink and kerf-closure radii

Using the supplied geometric relationship, Rclosure = (Do/2) × (P/k − 1) = (2.000/2) × (1.000/0.030 − 1) = 32.333 mm. The solver-reported kink radius is 32.271 mm. The difference is 0.062 mm, approximately 0.19% of the closure radius. The run reports “Kerf-Closure Before Kink,” consistent with the calculated closure and kink radii being nearly coincident.

4. Qualitative Interpretation

For the same cross-section and listed slot-pattern parameters, Nitinol’s lower elastic modulus predicts lower axial, bending, and torsional rigidity than annealed 304 stainless steel, along with lower radial crush resistance. The reported Nitinol outputs follow that direction.

The run reports a permanent-set bend radius of 12.121 mm and a kink radius of 32.271 mm. These are separate limits: the result indicates the modeled kink limit is reached at a larger bend radius than the modeled permanent-set limit. Therefore, the result supports a distinction between recoverable deformation and structural kinking; it does not support a claim that Nitinol eliminates kinking.

The material and structural behavior described here is the behavior represented by the CathCAD® Hypotube calculation and the supplied run. It should not be generalized to all Nitinol conditions or interpreted as a clinical performance claim.

5. Validity, Scope, and Limitations

- Valid for a software/model-behavior verification: the test exercises the Nitinol material selection, the 6.0% recoverable-strain criterion, small-strain stiffness and crush outputs, and the predicted relationship between geometric kerf closure and kink radius.
- The stainless comparison is not perfectly length-matched. The Nitinol section length is 4.000 mm; the cited 304 stainless steel Case 3 section length is 8.000 mm. The cross-section and listed pattern parameters are stated to match, but differing section length can affect boundary and end effects. The ratios are useful comparative checks, but should not be presented as a strictly controlled same-length material substitution without a matched 4.000 mm stainless reference or documented length-effect analysis.
- The reported outputs and calculations were supplied from the verification run and notes. This report records and checks their arithmetic; it does not independently rerun the solver or experimentally validate the predictions.

- The comparison supports internal engineering consistency, not full physical validation. Prototype testing with specified Nitinol stock, heat treatment, processing, and test conditions would be needed to validate physical performance.
- The user confirmed that the Nitinol recoverable-strain setting was updated to 6.0%; this report uses that current setting.

6. Conclusion

The Nitinol verification case is suitable for demonstrating that CathCAD® Hypotube applies the configured Superelastic Nitinol material treatment and produces outputs that are broadly consistent with the stated pre-run expectations and independent calculations. The strongest numerical agreement is the kerf-closure check (32.333 mm calculated versus 32.271 mm reported). Stiffness and crush ratios are close to material-property scaling estimates, with deviations ranging from about 1.2% to 2.6%. The permanent-set radius is within the expected range and about 3.0% from the strain-scaling estimate.

Disposition: PASS for the defined model-behavior checks, with the section-length comparison limitation recorded. Do not characterize this as experimental validation or claim that Nitinol eliminates kinking.